Risk Assessment Work Plan
Boeing Realty Corporation
Former C-6 Facility
Los Angeles, California

Prepared for

Boeing Realty Corporation
3760 Kilroy Airport Way
Suite 500
Long Beach, California 90806

Prepared by

Ogden Environmental and Energy Services Co., Inc.
5510 Morehouse Drive
San Diego, California 92121
(858) 458-9044

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A	Example Risk Assessment Report Template

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LIST OF ACRONYMS AND ABBREVIATIONS

ADI	average daily intake
ALCOA	Aluminum Company of America
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
Boeing	The Boeing Company
BRC	Boeing Realty Corporation
Cal-EPA	California Environmental Protection Agency
CDC	Center for Disease Control
CLP	Contract Laboratory Program
cm^2	square centimeter
cm^3/g	cubic centimeters per gram
COPC	chemical of potential concern
CR	cancer risk
CSC	Columbia Steel Company
CSM	conceptual site model
CTE	central tendency exposure
DAC	Douglas Aircraft Company
DTSC	Department of Toxic Substances Control
ECAO	Environmental Criteria and Assessment Office
EPC	exposure point concentration
g/m^2-hr	grams per square meter per hour
GC/MS	gas chromatography/mass spectrometry
GIS	geographic information system
HEAST	Health Effects Assessment Summary Table
HI	hazard index
HQ	hazard quotient
ICP	inductively coupled plasma
ILM	International Light Metals
IRIS	Integrated Risk Information System
kg	kilogram
kg/L	kilograms per liter
LADI	lifetime average daily intake
LARWQCB	Los Angeles Regional Water Quality Control Board
LOAEL	lowest-observed-adverse-effect level
m/s	meters per second
m^3	cubic meter

m^3/kg	cubic meters per kilogram
MDL	method detection limit
$mg/hr\text{-}m^2$	milligrams per hour per square meter
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mm	millimeter
MSL	mean sea level
NOAEL	no-observed-adverse-effect-level
NPL	National Priority List
OEHHA	Office of Environmental Health Hazard Assessment
Ogden	Ogden Environmental and Energy Services Co., Inc.
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEA	preliminary endangerment assessment
PEF	particulate emission factor
PRE	preliminary risk evaluation
PRG	preliminary remediation goal
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QC	quality control
RAGS	Risk Assessment Guidance for Superfund
RAWP	Risk Assessment Work Plan
RCRA	Resource Conservation and Recovery Act
RDL	reportable detection limit
RfD	reference dose
RME	reasonable maximum exposure
SAP	Sampling and Analysis Plan
SF	slope factor
SQL	sample quantitation limit
SVOC	semivolatile organic compound
TIC	Tentatively Identified Compound
TPH	total petroleum hydrocarbons
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VOC	volatile organic compound

µg/dL	micrograms per deciliter
µg/L	micrograms per liter

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SECTION 1
INTRODUCTION

This Risk Assessment Work Plan (RAWP) describes a standardized risk assessment methodology to conduct human health risk assessments for Parcel C of the Boeing Realty Corporation (BRC) Former C-6 Facility in Los Angeles, California. The approximate location of the Former C-6 Facility Parcel C property (herein referred to as the "subject property") is depicted in Figure 1-1. This RAWP has been prepared by Ogden Environmental and Energy Services Co., Inc. (Ogden) for BRC in support of its efforts to redevelop the subject property. Phase II soil and groundwater investigations are currently being conducted at the subject property. Data from these and historical investigations will be used in support of the risk assessments.

The purpose of this RAWP is to establish a standardized, regulatory-approved approach to assess potential human health risks associated with potential exposure to hazardous chemicals at the subject property released during historical manufacturing-related operations conducted at and in the vicinity of the subject property.

1.1 Regulatory Agency Oversight

The lead regulatory agency providing oversight for both investigation activities and risk assessments is the Los Angeles Regional Water Quality Control Board (LARWQCB). The California Environmental Protection Agency's (Cal-EPA's) Office of Environmental Health Hazard Assessment (OEHHA) will review the risk assessments for the LARWQCB.

1.2 Objective and Scope of the Risk Assessment Work Plan

The objective of the RAWP is to provide a consistent approach for risk assessments at various exposure areas within the subject property. The subject property may be divided into smaller exposure areas for evaluation depending on the spatial distribution of contaminants. The risk assessments will address potential human exposure to chemicals currently existing in impacted soil and groundwater as well as potential future exposure due to chemical migration. Each exposure area may have multiple chemical source areas, and similar chemicals, similar exposure pathways, and receptors. As such, development

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of a consistent technical approach for all exposure areas at the subject property is the first step in the risk assessment process.

Once this work plan is approved by LARWQCB/OEHHA, the methodology will be applied to assess potential human health risks associated with chemicals of potential concern identified in surface and subsurface soils, and groundwater.

The focus of the RAWP is on human health. The subject property is located in a highly industrialized area of Los Angeles, California, and therefore does not provide sufficient habitat or resources for ecological receptors. Because the purpose of the risk assessments is to provide BRC with information for making risk management decisions related to the future development of the subject property, the human health risk assessments will assess potential exposures to receptors associated with the proposed future land use(s) of the subject property and will be presented in such a manner as to expedite site redevelopment.

The onsite soil is being investigated in two general depth intervals: shallow soil (herein defined as soil present from the ground surface to a depth of 12 feet below ground surface [bgs]) and deep soil (herein defined as soil present from 12 feet bgs to the groundwater table). Shallow soil is the primary focus of the soil investigation since it is most likely to be impacted. In addition, future receptors have the greatest potential exposure to shallow soil, shallow soil is most likely to be disturbed during site redevelopment, and it is more readily accessible for remediation (e.g., can be more easily removed compared to deeper soil). Deep soil impacts are more likely to pose a threat to groundwater quality, a wider range of remediation options may be considered for deep soil, and remediation of deep soil may require a longer time frame than shallow soil. The groundwater investigation is focusing on evaluation of impacts to shallow groundwater. Thus, the risk assessment will present potential risk/hazard so that risk management decisions may be made separately for shallow soil, deep soil, and shallow groundwater.

While risk assessment guidance from both the United States Environmental Protection Agency (USEPA) and Cal-EPA will be considered in the risk assessment process, the general risk assessment framework used in the development of this RAWP is the *Outline of a Site-Specific Health Risk Assessment Workplan* prepared by Dr. Julio Salinas of OEHHA (OEHHA 2000).

The RAWP for the subject property includes the following tasks:

- establish the requirements for data to be used for the risk assessments
- evaluate background inorganic chemical concentrations, and possibly background organic chemical concentrations, if deemed applicable
- identify the criteria for selection of chemicals of potential concern (COPCs) for human health risk assessment
- establish a conceptual model to identify human receptors, exposure pathways, exposure points, and exposure mechanisms
- establish the procedure for human health toxicity assessments
- develop the procedure to characterize human health risks, including the establishment of risk criteria

1.3 Facility Background and Historical Onsite Operations

The subject property, located at 19503 South Normandie Avenue in Los Angeles, California, consists of Buildings 1, 2, 3, 19, 20, 32, and 66. A figure depicting the approximate location of the subject property is presented as Figure 1-1. A site plan is presented as Figure 1-2.

The following two reports prepared by Kennedy/Jenks Consultants were reviewed to obtain historical information for the subject property:

- *Sampling and Analysis Plan, Boeing Realty Corporation's C-6 Facility – Parcel C, Los Angeles, California,* dated August 16, 2000
- *Addendum A, Sampling and Analysis Plan, Boeing Realty Corporation's C-6 Facility – Parcel C, Los Angeles, California,* dated September 12, 2000

A review of the August 16, 2000, report indicates that the subject property was farmland prior to the 1940s, and that the C-6 Facility was constructed by the Defense Plant

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Corporation in 1941 as part of an aluminum reduction facility. The facility was operated by the Aluminum Company of America (ALCOA) until 1944. Then, from late 1944 until 1948, the facility was used for warehousing by the War Assets Administration. In 1948, the subject property was acquired by the Columbia Steel Company (CSC). In March 1952, the U.S. Navy purchased the subject property from CSC and Douglas Aircraft Company (DAC) was retained as the operator of the facility for the manufacturing of aircraft and aircraft parts. DAC purchased the C-6 Facility from the U.S. Navy in 1970 and continued manufacturing aircraft components until 1992. A limited amount of assembly and warehousing activities continued through mid-2000. The facility is currently being demolished for subsequent light industrial/commercial redevelopment.

A summary of the historical uses of various onsite buildings is presented below.

- **Building 1** - Building 1, constructed in the early 1940s, comprised approximately 250,000 square feet. During ALCOA operations, this building consisted of three separate structures, used for carbon baking activities. During operations by DAC, the three structures were combined and a basement was constructed. The basement was reportedly used for parts and records storage and for a painting area. The remainder of the building housed various metal finishing processes such as heat treating, milling, and pressing, and reportedly also contained an emissions scrubber and waste treatment area, a pump house, underground storage tanks (USTs), dip tanks, drop hammer pits, and transformers.

- **Building 2** - Building 2, constructed in the early 1940s, comprised approximately 1,000,000 square feet. During ALCOA operations, this building was used for various aluminum reduction operations. During operations by DAC, this building was used for parts manufacturing, assembly, and storage.

- **Building 3** - Building 3, constructed in the early 1940s, comprised approximately 168,000 square feet. During ALCOA operations, this building housed a rectifier. During operations by DAC, this building primarily housed administrative offices. This building also historically contained a small paint laboratory, a chemical laboratory, an UST, and two electrical transformers.

- **Building 19** - Building 19, constructed in the early 1940s, comprised approximately 7,500 square feet and was historically used as the security office and emergency services offices for the facility.

- **Building 20** - Building 20, constructed in the early 1940s, was the vehicle maintenance area of the facility and contained the battery recharging area, a 3-stage clarifier draining a steam-cleaning booth, an aboveground motor oil tank, hydraulic lifts, a condensation pit, and gasoline USTs and an associated fuel dispensing island.

- **Building 32** - Building 32, constructed in the 1980s, was used as a cafeteria and meeting hall. A salvage yard was located north of Building 32. Other areas adjacent to Building 32 historically contained a transfer area, painting and paint storage area, drains, oil storage area, and USTs.

- **Building 66** - Building 66, constructed in 1972, comprised approximately 200,000 square feet. Prior to construction, the area was a storage yard. After construction, this building was used for assembly of shipping supplies and light tool cutting.

Chemicals used at the subject property have generally included volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPH), and metals.

1.4 ENVIRONMENTAL SETTING

Information regarding regional geologic and hydrogeologic setting and surface water was obtained primarily from the previously referenced August 16, 2000, report prepared by Kennedy/Jenks Consultants and the report entitled *McDonnell Douglas Conceptual Design of Final Soil and Groundwater Remediation System at the Douglas Aircraft Company, C-6 Facility*, prepared by Montgomery Watson and dated March 1994. A generalized hydrogeologic cross section of the site is presented as Figure 1-3.

1.4.1 Regional Geology

The subject property is situated at an elevation of approximately 50 feet above mean sea level (MSL) and is located within the Torrance Plain physiographic area of the Los Angeles Basin. The Torrance Plain is underlain by Pleistocene deposits of the Lakewood

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Formation, which is underlain by the Pleistocene San Pedro Formation. The upper portion of the Lakewood Formation is comprised of stream channel and floodplain deposits of gravel, sand, sandy silt, and clay. The lower portion of the Lakewood Formation is comprised of both continental and marine deposits. The maximum thickness of the Lakewood Formation is approximately 150 feet. The San Pedro Formation is also comprised of continental and marine deposits that reach a thickness of approximately 1,000 feet within the Coastal Plain of Los Angeles County. Since soil contamination is anticipated to be restricted to the upper tens of feet at the subject property, the San Pedro Formation is not expected to be encountered during the Phase II investigations.

1.4.2 Regional Hydrogeology

Known water-bearing deposits in the Lakewood and San Pedro Formations extend to depths greater than 1,000 feet bgs near the subject property. Aquifer systems identified in this area include the shallow aquifer system of the Lakewood Formation and the deep aquifer system of the San Pedro Formation. The shallow aquifer system, present within the Lakewood Formation, includes the Bellflower Aquitard and the Artesia and Gage Aquifers. The Bellflower Aquitard is the uppermost water-bearing zone beneath the subject property and is a semiconfining layer to underlying aquifers. The groundwater table within the Bellflower Aquitard has been encountered onsite to depths of approximately 70 feet bgs.

The base of the Bellflower Aquitard is reportedly present at a depth of approximately 150 feet bgs. The Bellflower Aquitard is known to have relatively low hydraulic conductivities due to the predominant fine-grained nature (a heterogeneous mixture composed primarily of low permeability sands and clays, with lenses of sandy and gravelly clays in some areas) of this unit. The hydraulic gradient in this uppermost groundwater was measured as 0.0007 feet per foot in July 1999. The groundwater flow direction is generally to the south. The Gage Aquifer, present beneath the Bellflower Aquitard, is a water-bearing zone of fine to medium sand and gravel. Its reported thickness is approximately 40 feet and is described as being of secondary importance as a water source.

The deeper aquifer system is within the San Pedro Formation. Major water-bearing zones within this formation include the Lynwood Aquifer and the Silverado Aquifer,

present at depths of approximately 300 and 500 feet, respectively. The Silverado Aquifer is an important groundwater source in the Coastal Plain and is considered a source of drinking water.

The LARWQCB has designated groundwater at and in the vicinity of the subject property as having existing beneficial uses for municipal and domestic supply, agricultural supply, industrial service supply, and industrial process supply. However, ambient water quality conditions in the shallow water bearing zones frequently do not meet water quality objectives for domestic uses. In addition, as indicated above, the Bellflower Aquitard has relatively low hydraulic conductivities. Thus, it will be assumed that the groundwater within the Bellflower Aquitard is not suitable for water supply purposes.

Since the Bellflower Aquitard is the uppermost water-bearing zone encountered at the subject property, the risk assessments will focus on possible exposures related to groundwater within the Bellflower Aquitard. Should it be determined that groundwater within other aquifers is impacted by site-related activities, the risk assessments will be expanded to address possible exposures related to these deeper water-bearing zones.

1.4.3 Surface Water

No surface water bodies are located within the bounds of or adjacent to the subject property. The ground surface in the area of the subject property is generally flat with an eastward gradient of approximately 20 feet per mile. Surface drainage is generally toward the Dominguez Channel, located approximately 1 mile east of the subject property. The Dominguez Channel flows southeastward toward the Los Angeles and Long Beach Harbors in San Pedro Bay.

1.5 Adjacent Properties

Properties adjacent to the subject property are used for light industrial and commercial purposes. Some of these properties may have impacted soil and groundwater beneath the subject property. Parcels A, B, and D of the Former C-6 Facility are situated adjacent to the north, west, and south of the subject property (Parcel C). In addition, two National Priority List (NPL) federal Superfund sites and one California Superfund site are situated adjacent to the Former C-6 Facility property, and three other known hazardous waste sites are located within 0.5 mile of the Former C-6 Facility property. These include:

- the Montrose Chemical NPL site and the Jones Chemical NPL site, both located adjacent to the south;

- the Del Amo NPL site, located approximately 1,500 feet to the east;

- the International Light Metals (ILM)/Lockheed Martin Resource Conservation and Recovery Act (RCRA) Mandatory Cleanup site, located adjacent to the west; and

- the Allied Signal State hazardous waste site and the Mobil Refinery State Superfund site, both located within 0.5 mile west of the Former C-6 Facility.

The approximate locations of each of the above-noted sites are depicted on Figure 1-4.

1.6 Work Plan Organization

A flowchart showing the general risk assessment process and RAWP organization is presented in Figure 1-5. A summary of the information presented in each of the sections of this RAWP is presented below:

- Section 1 describes the current and historical manufacturing-related operations at the subject property; the environmental setting and adjacent properties; the scope, objectives, and approach of the RAWP; and the regulatory authorities under which the risk assessments will be performed.

- Section 2 presents the data quality requirements and objectives for the risk assessments.

- Section 3 describes the hazard identification process, including the identification of COPCs and methods for evaluating background concentrations for inorganic chemicals.

- Section 4 describes the conceptual site model for the subject property, and includes the identification of potential human receptors and the evaluation of possible exposure pathways.

- Section 5 presents the methods for statistical evaluation of analytical data and the estimation of exposure point concentrations.

- Section 6 presents methods for conducting conservative screening risk assessments at each exposure area in order to eliminate from further consideration any exposure area that clearly does not pose a significant risk to human health.

- Section 7 presents the methods used to estimate human intake. Both deterministic and probabilistic methods are described in this section.

- Section 8 describes the approach for selecting toxicity values for use in the risk assessments, and includes the hierarchy for selecting toxicity values from various sources.

- Section 9 describes proposed risk decision criteria.

- Section 10 describes the human risk characterization procedure for both deterministic and probabilistic methods, and includes a sensitivity analysis to assist risk managers with understanding those factors having the greatest impact on risk.

- Section 11 presents the references cited in this document.

Tables and figures for each section are presented at the end of their respective sections.

1.7 DEFINITIONS

Terms are used in this RAWP that have specific meaning with respect to the subject property or the processes described. The following are definitions of select terms:

1. Parcel C of the former C-6 Facility will herein be referred to as the "subject property."

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2. An "exposure area" is the minimum area that will sustain an assumed exposure to humans receptors. It is likely that the subject property will contain multiple exposure areas.

3. An "open area" is an area defined as not having current or historical industrial (chemical) operations, where it is likely that background soil samples may be obtained (i.e., within vehicle parking lots or open space).

4. A "chemical of potential concern" (COPC) is a potentially site-related chemical with data of sufficient quality for use in quantitative human health risk assessment.

5. "Pristine conditions" are naturally occurring concentrations of chemicals in soils at locations unaffected by human activity (DTSC 1997).

6. "Ambient conditions" are concentrations of compounds in soils in the vicinity of a site that are unaffected by site-related activities. Ambient conditions are sometimes referred to as "local background" (DTSC 1997).

7. A "human receptor" is a hypothetical individual who may be exposed to compounds in the environment. Receptors are often identified by the behaviors that determine how or with what intensity they may be exposed, such as "workers" or "residential receptors."

8. An "exposure route" is a mechanism of uptake. Environmentally relevant exposure routes typically include inhalation, ingestion, and absorption through the skin.

9. An "exposure pathway" is defined by USEPA (1989, 1992d) as consisting of four elements: (a) a source and mechanism of chemical release; (b) a retention or transport mechanism through an environmental medium; (c) a point of potential contact with the impacted medium (i.e., an exposure point); and (d) an exposure route at the exposure point. If any of these elements is missing, the exposure pathway is considered "incomplete," and compound uptake via the pathway would not occur.

10. A "method detection limit" (MDL) is defined by USEPA (1992a) as the minimum amount of an analyte that can be routinely identified using a specific method.

11. A "sample quantitation limit" (SQL) is defined by USEPA (1992a) as the MDL adjusted to reflect a sample-specific action such as dilution or use of a smaller sample aliquot for analysis due to matrix effects or the high concentration of some analytes.

12. A "contract required quantitation (detection) limit" (CRDL) is defined by USEPA (1992a) as the SQL that has been shown through laboratory validation to be the lower limit for confident quantitation and to be routinely within the defined linear ranges of the required calibration procedures. The CRDLs as presented herein are, thus, estimated best-case SQLs.

13. An "exposure point concentration" (EPC) is the concentration of a COPC in a medium at the location where a receptor is assumed to make contact with that medium. Depending on the nature of the exposure, an EPC may be estimated at a specific point, or may need to be averaged about an "exposure area" (e.g., the soil surface). It may also be necessary to take into account the potential for the EPC to change over time.

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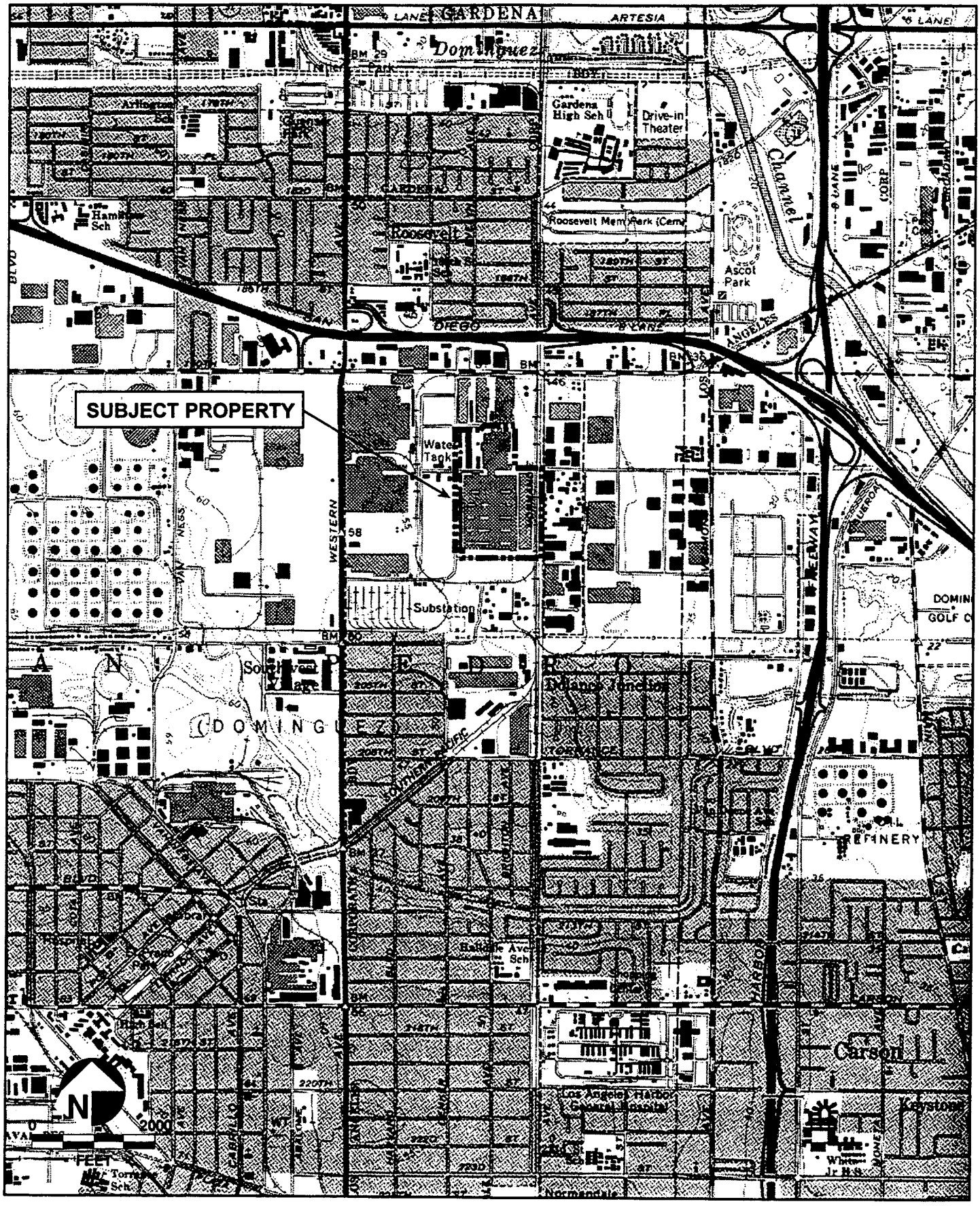

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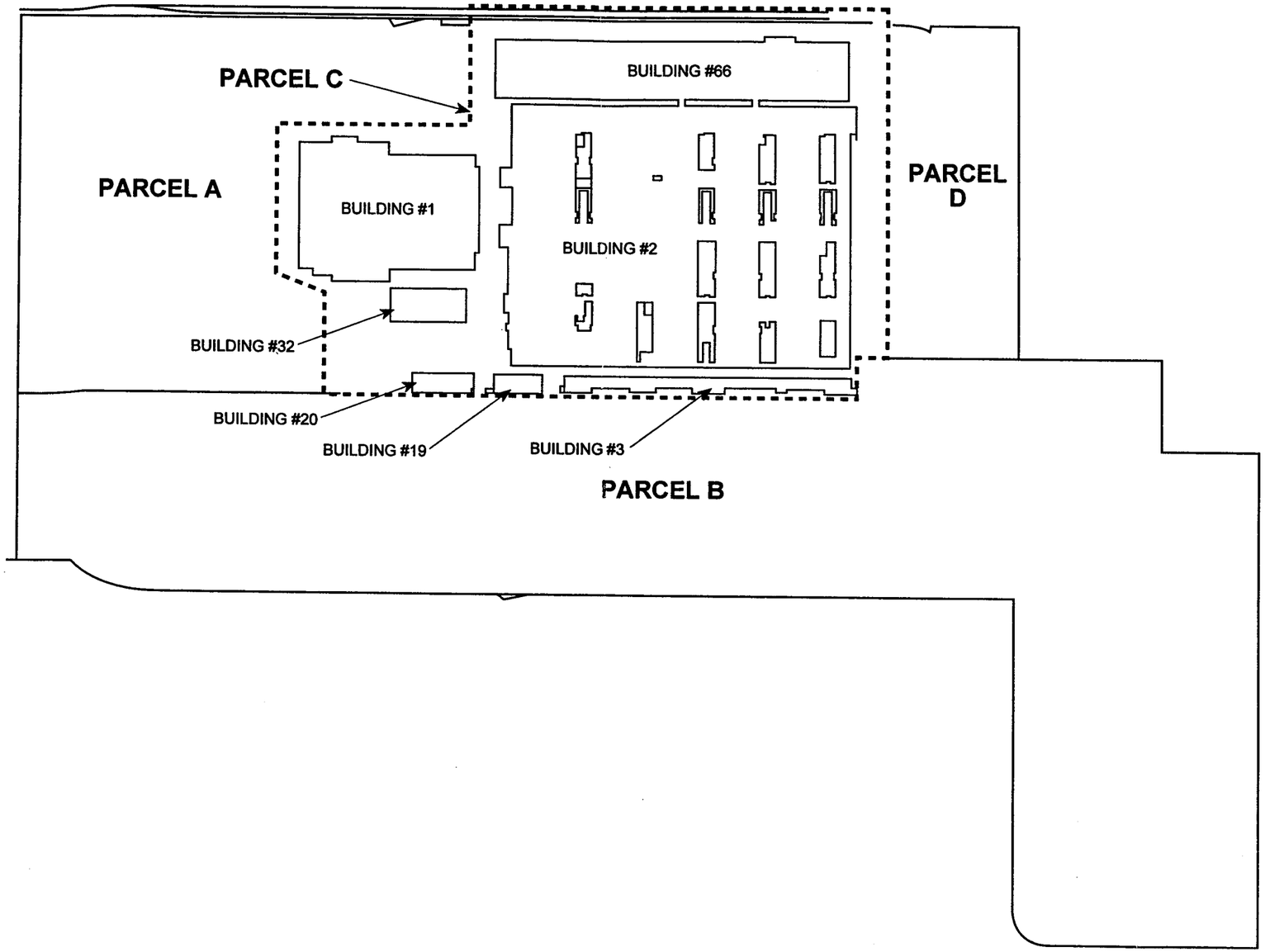
Subject Property Location
BRC Former C-6 Facility
Los Angeles, California

FIGURE
1-1

Boeing/Boeing C_6/Graphics/Project Location.FH8



SOURCE: Kennedy/Jenks Consultants, Sampling and Analysis Plan,
Boeing Realty Corporation's C-6 Facility-Parcel C, Los Angeles California, 16 August 2000

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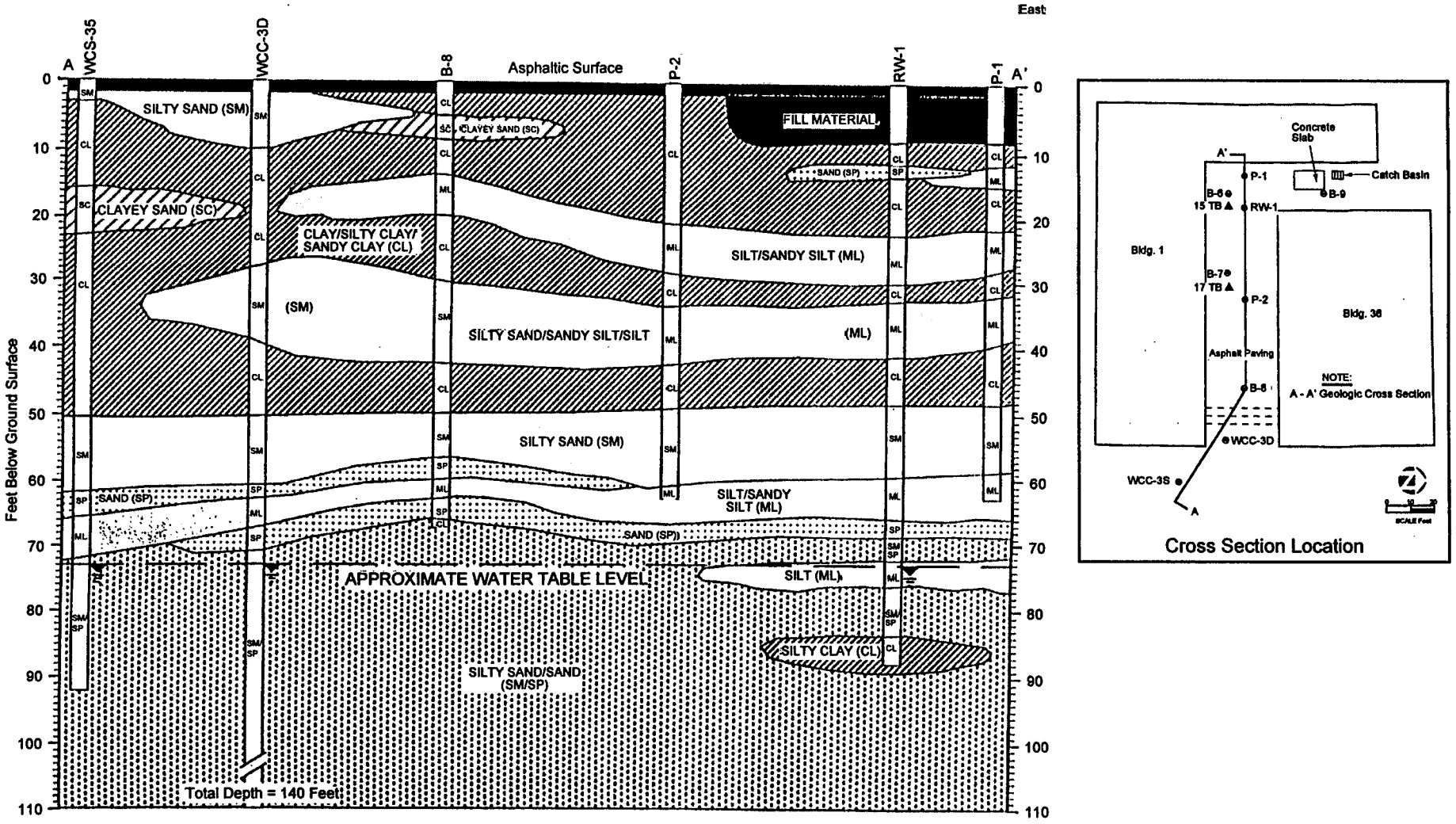
Site Plan
BRC Former C-6 Facility
Los Angeles, California

FIGURE
1-2

Boeing/Boeing C-6/Graphics/Site Plan Fig1_2.Fh8



Cross Section Location

SOURCE: Montgomery Watson, McDonnell Douglas Conceptual Design of Final Soil and Groundwater Remediation System at the Douglas Aircraft Company, C6 Facility, March 1994

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Hydrogeologic Cross-Section A - A'
BRC Former C-6 Facility
Los Angeles, California

FIGURE
1-3

Boeing/Boeing C-6/Graphics/X_SEC_6.Fh8

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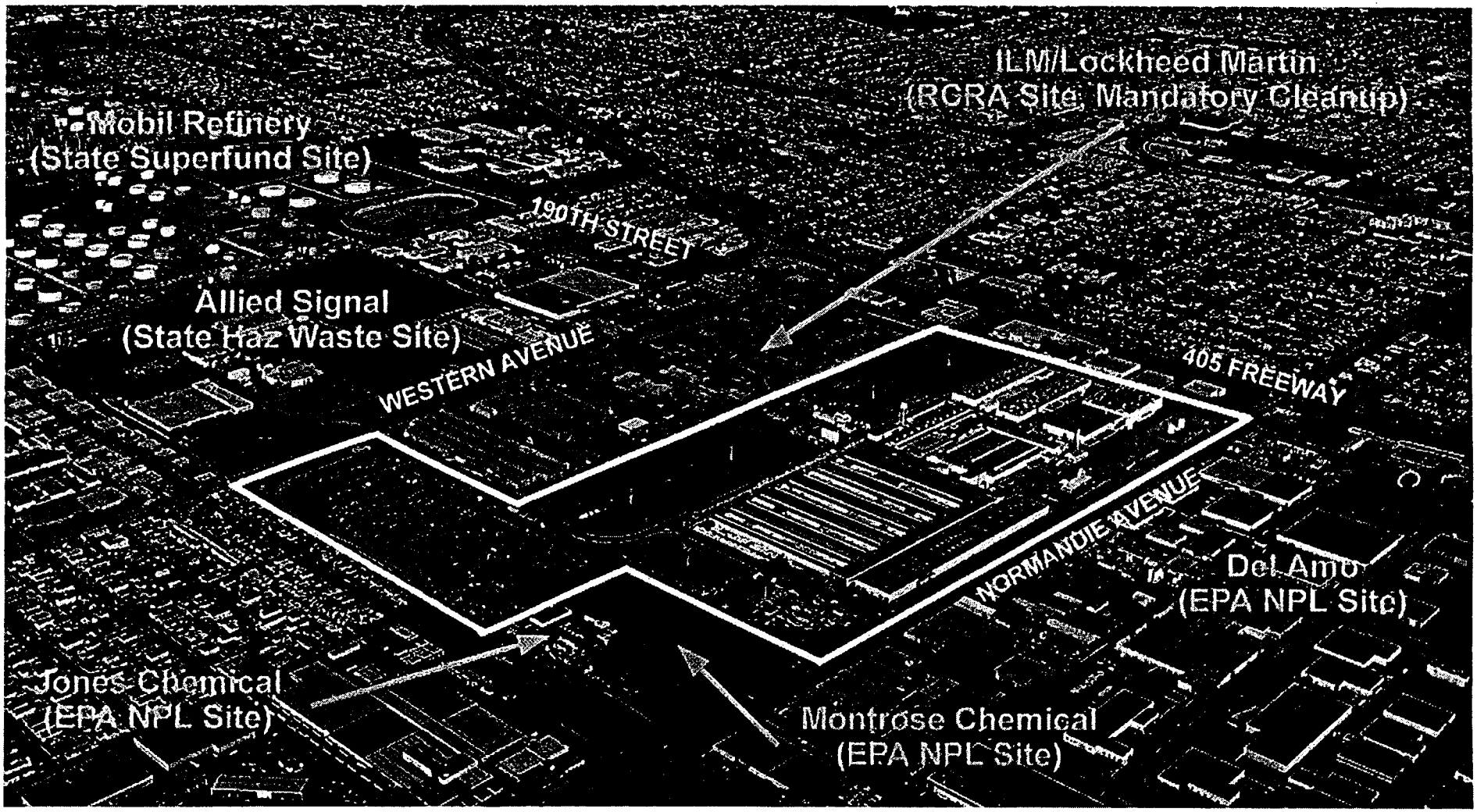

OGDEN

Surrounding Properties in Proximity to BRC Former C-6 Facility
BRC Former C-6 Facility
Los Angeles, California

FIGURE
1-4

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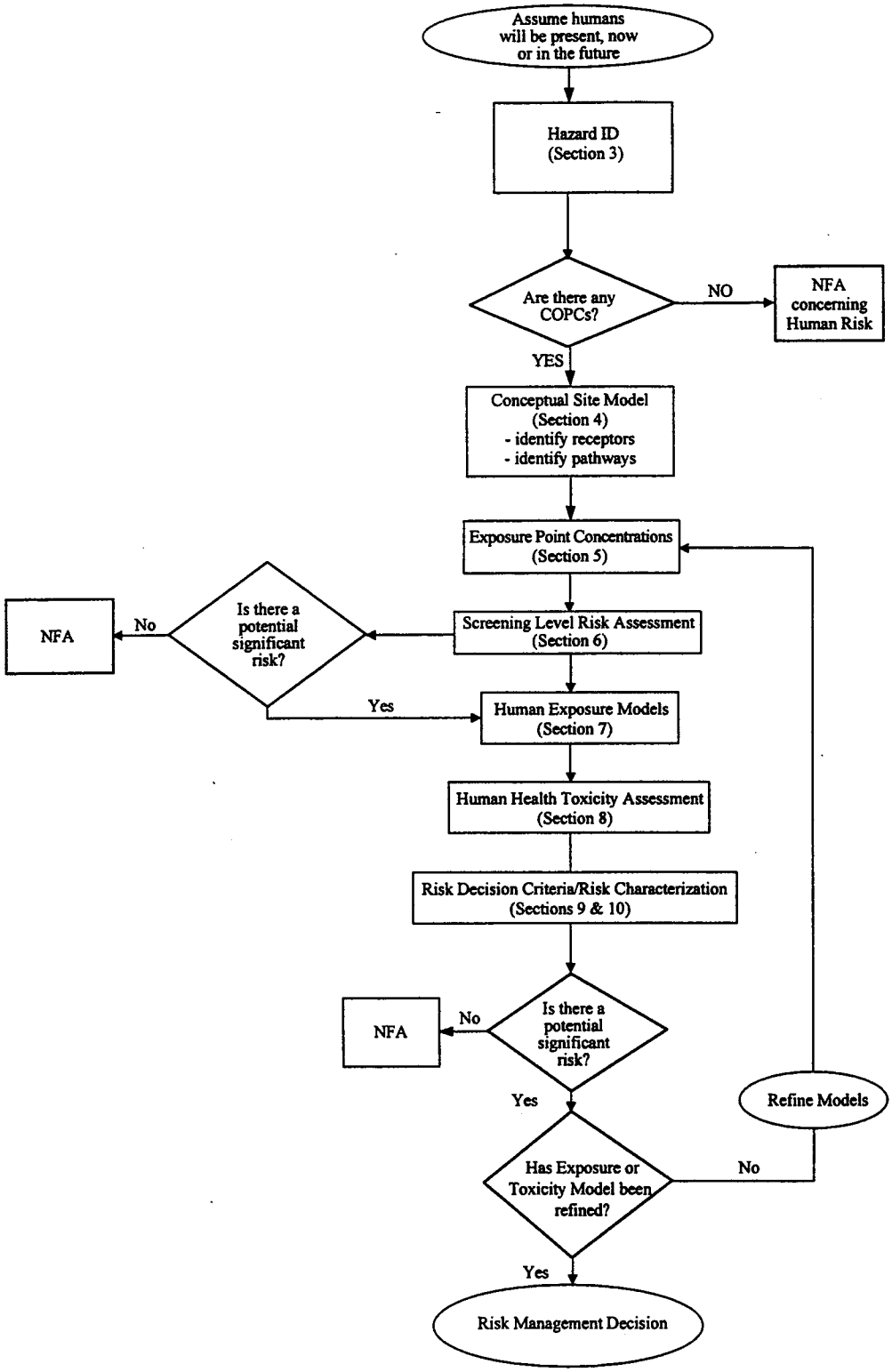

NOTES:
NFA - no further action
COPCs - chemicals of potential concern

OGDEN

Risk Assessment Flowchart
BRC Former C-6 Facility
Los Angeles, California

FIGURE
1-5

Boeings/Boeing C-6/Graphics/Risk Flowchart_1_5.FH8

SECTION 2
DATA REQUIREMENTS AND OBJECTIVES

All sample analytical results will be evaluated to determine their suitability for use in the risk assessments. The data quality assessment performed on the sampling results will follow the criteria provided by USEPA in the *Guidance for Data Usability in Risk Assessment (Part A), Final* (USEPA 1992a). Thus, the criteria specified by USEPA and summarized in Sections 2.1 through 2.5 will be met for sampling data results used in risk assessments for the subject property. Findings of the data quality assessment will be presented in the individual risk assessment reports.

Although USEPA provides a comprehensive framework for risk assessment data requirements, specific data requirements for any particular data point will be established based on how that data point will be used during the risk assessment (e.g., what decision is to be made based on that data) (USEPA 1992). The establishment of any alternative data requirements will be approved by the LARWQCB/OEHHA prior to use in any risk assessment.

2.1 Data Source Review

The data source review evaluates the analytical methods performed on the sample with respect to site use information. The objective of the review is to ensure that appropriate analytical methods are used to identify all potential COPCs for each environmental medium of interest.

2.2 Documentation

The analytical database will contain sample results from historical investigation activities and those associated with the currently conducted Phase II investigation activities. A subset of both the historical and Phase II analytical data will undergo data validation procedures. In addition, the Phase II field sampling program may be reviewed. The analytical data validation procedures will be conducted to evaluate the manner in which samples were managed by the field sampling teams and receiving laboratories. The field program review will be conducted to ensure that each analytical result is associated with a sampling location and that appropriate procedures were used to collect the environmental sample. The three types of documentation that will be used to trace

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samples and analytical methods are chain-of-custody forms, standard operating procedures, and field sampling and analytical records.

Data obtained from previous assessment reports containing historical data will be reviewed. The criteria used to evaluate information contained in the previous reports may include:

- map(s) of sampling locations
- rationales for sampling design and procedures
- identification of sample collection and preparation methods
- identification of analytical methods
- analytical results
- sample quantitation limits (SQLs)
- sample-specific qualification of the analytical results
- a description of the data review
- a description of the field conditions and physical parameters

2.3 Analytical Methods and Detection Limits

For an analytical result to be usable for assessing risk, the sample collection, preparation, and analytical methods should appropriately identify the chemical form or species, and the SQL should be at or below a concentration that is associated with toxicologically relevant (e.g., benchmark) levels. The significance of SQLs greater than benchmark levels will be evaluated on a case-by-case basis in the discussion of uncertainty. Analytical suites, methods, and the chemicals and/or chemical classes to be analyzed for in samples to be collected during the Phase II investigation activities are summarized in Table 2-1.

2.4 Data Review and Validation

Sample data used in the risk assessment will be reviewed and validated. The data will be validated following the guidance set forth in USEPA's *Contract Laboratory Program National Functional Guidelines for Organic Data Review* (1994a), and USEPA's *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (1994b).

Soil and water sample data will be validated based on the following criteria: sample management (appropriate containers, preservatives, documented chain-of-custody, and holding times), method blank sample results, blank spikes and laboratory control sample results, surrogate recoveries, matrix spike/matrix spike duplicate recoveries and precision, reporting limits, and field quality control (QC) sample results (equipment rinsate blanks, field blanks, and field duplicates).

A more detailed validation may be performed on selected data. The additional review may include, but is not limited to, evaluation of calibration data; gas chromatography/mass spectrometry (GC/MS) tuning; internal standards; confirmation analyses; inductively coupled plasma (ICP) interference checks; post-digestion spikes; all raw data (quantitation sheets, extraction benchsheets, chromatograms, and analysts log sheets); and all information pertinent to the collection, extraction, and analysis of the samples.

The data validation procedures are designed to meet overall project data quality objectives. Data qualifiers will be assigned to data with associated qualification codes, which denote the specific reason for the qualification. The data qualifiers that may be assigned to a sample with a qualification code are shown in Table 2-2. A list of qualification codes that explain the reason for the data qualifier is provided in Table 2-3. Section 5 presents specifications for the use of qualified data.

2.5 Data Quality Indicators - Representativeness and Completeness

Data will be evaluated to determine how well chemical impacts are characterized. Data representativeness is an evaluation of site characterization, i.e., how well the samples describe site conditions (e.g., are samples appropriately placed to reveal potential releases and have all chemicals potentially related to activities at the subject property been analyzed). Completeness relates to whether enough sample results have been retained after validation to adequately characterize the subject property. Additionally, the groundwater data will be reviewed to determine if the variability of chemical concentrations in time and space are adequately characterized. Data evaluation for completeness also provides a measure of confidence in the conclusions made from the data.

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Table 2-1

SAMPLE ANALYTICAL SUITES

Laboratory Analytical Method	Types of Chemicals
USEPA Method 8260B	Volatile organic compounds (including 1,4-dioxane)
USEPA Method 8015M	Total petroleum hydrocarbons (extended range)
USEPA Method 8082	Polychlorinated biphenyls (PCBs)
USEPA Method 8270C	Semivolatile organic compounds (except PAHs)
USEPA Method 8310	Polycyclic aromatic hydrocarbons (PAHs)
USEPA Method 6010B/6020/7000	Metals (CCR Title 22 metals, including total chromium)
USEPA Method 7196A	Hexavalent chromium
USEPA Method 314.0	Perchlorate
USEPA Method 9010B/9014	Total cyanide
USEPA Method 9012	Amenable Cyanide

Table 2-2

DATA QUALIFIER REFERENCE TABLE

Qualifier	Organics	Inorganics
U	The analyte was analyzed for, but was not detected above the reported SQL.	The material was analyzed for, but was not detected above the level of the associated value.
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.	The associated value is an estimated quantity.
N	The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification."	Not applicable.
NJ	The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.	Not applicable.
UJ	The analyte was not deemed above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.	The material was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and to meet quality control criteria. The presence or absence of the analyte cannot be verified.	The data are unusable. (Note: Analyte may or may not be present.)

Table 2-3 (Page 1 of 2)

QUALIFICATION CODE REFERENCE TABLE

Qualifier	Organics	Inorganics
H	Holding times were exceeded.	Holding times were exceeded.
S	Surrogate recovery was outside QC limits.	The sequence or number of standards used for the calibration was incorrect
C	Calibration %RSD or %D was noncompliant.	Correlation coefficient is <0.995.
R	Calibration RRF was <0.05.	%R for calibration is not within control limits.
B	Presumed contamination from preparation (method) blank.	Presumed contamination from preparation (method) or calibration blank.
L	Laboratory Blank Spike/Blank Spike Duplicate %R was not within control limits.	Laboratory Control Sample %R was not within control limits.
Q	MS/MSD recovery was poor or RPD high.	MS recovery was poor.
E	Not applicable.	Duplicates showed poor agreement.
I	Internal standard performance was unsatisfactory.	ICP ICS results were unsatisfactory.
A	Not applicable.	ICP Serial Dilution %D was not within control limits.
M	Tuning (BFB or DFTPP) was noncompliant.	Not applicable.
T	Presumed contamination from trip blank.	Not applicable.
+	False positive – reported compound was not present. Not applicable.	Not applicable.
-	False negative – compound was present but not reported.	Not applicable.
F	Presumed contamination from FB or ER.	Presumed contamination from FB or ER.
$	Reported result or other information was incorrect.	Reported result or other information was incorrect.
?	TIC identity or reported retention time has been changed.	Not applicable.
D	The analysis with this flag should not be used because another more technically sound analysis is available.	The analysis with this flag should not be used because another more technically sound analysis is available.
P	Instrument performance for pesticides was poor.	Post-digestion spike recovery was not within control limits.

Table 2-3 (Page 2 of 2)

QUALIFICATION CODE REFERENCE TABLE

Qualifier	Organics	Inorganics
*#	Unusual problems found with the data. The number following the asterisk (*) is the reference to a description of where the problem can be found.	Unusual problems found with the data. The number following the asterisk (*) is the reference to a description of where the problem can be found.

2BFB = bromofluorobenzene
D = difference
DFTPP = decafluorotriphenylphosphine
ER = equipment rinsate
FB = field blank
ICP = inductively coupled plasma
ICS = internal check standard
MS/MSD = matrix spike/matrix spike duplicate
QC = quality control
R = recovery
RPD = relative percent difference
RRF = relative response factor
RSD = relative standard deviation
TIC = tentatively identified compound

SECTION 3
HAZARD IDENTIFICATION

All chemical analytes detected in site samples will be considered for inclusion in the risk assessment. It is neither appropriate nor necessary to carry every chemical through the risk assessment process to assess potential site-related human health risks. The Department of the Toxic Substances Control (DTSC) (1992) and USEPA (1989) provide guidance on methods for selecting COPCs for purposes of risk assessment.

Section 3.1 describes the process for selecting COPCs for evaluation within risk assessments for the subject property. The selection of COPCs relies on a multistep process of screening data from the subject property. Among the criteria discussed below is an evaluation of whether site-related chemicals are consistent with background. Site-related chemicals are herein defined as those chemical contaminants at the subject property that are associated with apparent releases during onsite historical manufacturing-related operations and during historical industrial activities conducted on properties in the vicinity of the subject property. Section 3.2 provides a description of the methodology for making this comparison.

3.1 COPC Selection Criteria

The goal of the risk assessment is to estimate the potential risks to human receptors from site-related chemicals under reasonable exposure scenarios (USEPA 1989). To ensure the focus of the risk assessment is on site-related chemicals, COPCs are selected using several criteria. The criteria used to select COPCs ensure that site-related chemicals that may pose a human health risk are included in the evaluation and in subsequent remedial response actions if risks are above acceptable levels. The following sequential criteria will be applied to select COPCs for human health risk assessment purposes:

1. A chemical is detected at the subject property using validated laboratory analyses.
2. Chemicals occur above a 5 percent detection frequency. The evaluation of detection frequency will be based on professional judgment with consideration of sample size, historical chemical use, SQLs, and relative concentrations.
3. Chemicals are present in excess of concentrations observed in laboratory or field blanks.

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4. For inorganic chemicals, the measured concentrations are in excess of background concentrations.

A decision flow diagram for identifying human health COPCs is shown in Figure 3-1.

3.1.1 Candidate Chemicals

The first step in the COPC selection process is the evaluation of candidate COPCs. Candidate COPCs are selected from chemicals that have been detected at the subject property and meet acceptable data quality requirements (USEPA 1989, 1992a). Any chemical detected in a usable data set will be a candidate COPC.

3.1.1.1 Data Validation

For those analytes that meet the quality assurance/quality control (QA/QC) requirements, the data will be sorted by environmental media (i.e., soil vapor, soil, and groundwater) and the SQL will be evaluated. Those chemicals detected in the validated samples will be included as candidate COPCs. It may also be necessary to retain undetected chemicals as candidate COPCs if the chemical may be site-related, and if SQLs in one or more samples are too high to adequately evaluate the presence or absence of the chemical. For purposes of this RAWP, a high SQL is defined as being inconsistent with CRDLs. CRDLs are the laboratory's estimate of what the SQL will be, based on optimal analytical conditions and theoretical sample weight. Table 3-1 presents CRDLs for analytical procedures based on optimal method performance, USEPA Contract Laboratory Program (CLP) requirements, or modified, when possible, to achieve detection limits at or below health-based criteria.

High SQLs will be evaluated on a case-by-case basis using best professional judgment and knowledge of historical operations at the subject property. Possible outcomes include:

- requesting additional sampling
- retaining the chemical on the COPC list
- determining that the higher SQL does not alter the decision to remove the chemical from the COPC list

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When a high SQL is used to remove a chemical from the COPC list, justification will be provided in the hazard identification section of the risk assessment report.

3.1.1.2 Tentatively Identified Compounds

A Tentatively Identified Compound (TIC) is reported based on an analytical pattern that approximately fits the mass spectra and retention time pattern of a particular chemical. By definition, a TIC's mass spectra pattern diverges sufficiently from the pattern in the analytical library that neither the identity nor reported concentration can be confirmed. TICs will not generally be considered as COPCs for the following reasons:

- The identity of a TIC is not as certain as chemicals identified in the analyte list. Thus, it is not clear whether the chemical is actually present.
- TICs are frequently general chemical classes (e.g., "C-8 chemicals") for which specific toxicity data are not available.
- TICs are frequently chemicals for which no toxicity data are available.

When TICs are encountered, the risk assessor may include the chemical as a COPC for purposes of "screening" the chemical in the risk assessment. However, the assessor may also offer a justification to eliminate the TIC from the COPC list based on (1) probability of the chemical identity (i.e., demonstrate that an attempt to identify the unknown chemical, based on judgment by an analyst, was not possible) or (2) infeasibility of doing a risk assessment due to lack of toxicological information. If a TIC is eliminated from the list of COPCs, it will be discussed in the uncertainty assessment of the risk assessment report.

3.1.2 Screening Candidate Compounds

Candidate chemicals are screened to determine whether they will be included as COPCs in the quantitative risk assessment. A serial multistep screening process will be used to evaluate candidate chemicals, including comparison of detected site concentrations to background concentrations, evaluation of frequency of detection, and consideration of blank contamination. Each of these steps is described in the following subsections. This process is considered a serial process since each criterion is applied to the candidate chemicals that remain after application of the previous selection criterion. For instance, the frequency of detection criterion will only be applied to chemicals that have been

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selected from the candidate COPC list because their concentrations are in excess of site-specific background.

3.1.2.1 Background

Soil samples collected from the subject property or from appropriately scaled exposure areas will be statistically compared to the background data set collected for the subject property using the two-tiered approach described in the DTSC (1997) guidance *Selecting Inorganic Constituents as Chemicals of Potential Concern for Risk Assessments at Hazardous Waste Sites and Permitted Facilities.* This approach is described in Section 3.2. Chemical analytes whose concentrations are determined not to be representative of concentrations in the background data set will be identified as candidate COPCs.

Both naturally occurring chemicals and anthropogenic chemicals meet the criteria for background chemicals as specified by USEPA (1989). USEPA defines the two sources of background chemicals that are considered in the risk assessment process as follows (USEPA 1989):

> naturally occurring levels, which are ambient concentrations of chemicals present in the environment that have not been influenced by humans ... [and] anthropogenic levels, which are concentrations of chemicals that are present in the environment due to human-made, nonsite sources.

Therefore, the USEPA definition of background is fully aligned with their definition of a COPC to the extent that only site-related chemicals are evaluated in the risk assessment, and those chemicals detected in site media that are not site-related are present due to natural sources or offsite anthropogenic sources.

DTSC (1997) further differentiates between natural and offsite anthropogenic sources by using the terms "pristine conditions" and "ambient conditions" as defined below:

> "Pristine conditions" are naturally occurring concentrations of chemicals in soils at locations unaffected by human activity.

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"Ambient conditions" are concentrations of chemicals in soils in the vicinity of a site but which are unaffected by site-related activities (also referred to as local background).

Hence, background levels of metals are the result of both natural and anthropogenic sources, as they can be characterized in the context of "pristine conditions" and "ambient conditions." Metals occur naturally within the geologic matrix and as a result of atmospheric deposition and other nonpoint sources (USGS 1984). Therefore, background levels of metals will be evaluated in the risk assessments conducted at the subject property. Background levels of organic chemicals (e.g., PAHs, dioxins) may also be evaluated in the risk assessments, should it be deemed applicable after review of laboratory data for background samples.

The proposed protocol, described in Section 3.2.1, is consistent with both state and federal regulatory guidance (DTSC 1992; USEPA 1989, 1992a,b).

3.1.2.2 Frequency of Detection

Analytes that are infrequently detected may be artifacts in the data due to sampling, analytical, or other errors. Analytes will be identified as COPCs if they are detected in greater than 5 percent of the samples at a site (USEPA 1989; DTSC 1992) or when use of a chemical at that area of the subject property is historically documented. Application of the selection criterion necessarily requires that 20 or more samples be in the candidate data set. Therefore, the frequency of detection step of the screening process will not be applied with fewer than 20 samples.

Professional judgment must be applied to findings with a frequency of detection between 0 and 5 percent. Thus, this step in the selection process includes reviewing data on a case-by-case basis and retaining an infrequently detected chemical as a COPC if:

- The chemical was historically present in processes associated with the subject property exposure area
- The chemical is potentially a breakdown product of other chemicals detected at the subject property/exposure area
- The chemical is present in other media (e.g., groundwater) within the subject property/exposure area

- The chemical is present in the same or other media in areas that may impact the subject property/exposure area (e.g., upgradient or adjacent areas)
- The chemical is detected at a concentration high enough relative to its toxicity to be cause for concern, even if its presence is limited. (The potential presence of a chemical in a "hotspot" such as described here may potentially impact health based on chronic and/or acute exposure assessment. Such evaluations require separate exposure assumptions and will be developed as needed)
- Samples with detections are grouped spatially, suggesting a potential source
- Other judgments make it difficult to rule out the possibility that a chemical is present at an environmentally relevant concentration

This evaluation will be discussed in an appropriate section of the risk assessment report.

3.1.2.3 Blank Contamination

In the event of blank contamination of samples, if a chemical is not associated with historical activities at the subject property and the analyte is a common laboratory contaminant, it will only be identified as a COPC if the concentration in any sample from the candidate data set is greater than ten times the concentration observed in the corresponding blank. If an analyte detected in the blank is not a common laboratory contaminant, it will be included as a COPC unless the observed concentrations are less than five times the corresponding blank. Common laboratory contaminants are:

- acetone
- 2-butanone
- methylene chloride
- toluene
- any common phthalate ester

As a practical matter, the validation procedures for many data sets (as described in Section 2) call for ranking a chemical as "nondetect" if observed site sample concentrations are less than tenfold or fivefold higher than blank sample concentrations of common laboratory contaminants or other chemicals, respectively. Thus, the evaluation of chemicals based on blank contamination may actually be applied within the data validation step.

If a chemical encountered in the sample blank does not meet the specifications for proportionally greater concentrations in site samples versus the sample blank but was associated with historical onsite activities, a decision will be made to either resample and/or reanalyze for the chemical or include the chemical as a COPC regardless of the blank contamination. Additionally, the chemical found in the blank will be included as a COPC if any of the following conditions are true:

- The chemical is present in other media within the subject property/exposure area
- The chemical is present in onsite media upslope, upgradient, or in areas adjacent to the exposure area
- The chemical is a breakdown product of other chemicals detected onsite at or adjacent to the exposure area

Where a portion of the site samples containing the chemical in question have concentrations greater than the corresponding blank criterion, but other samples have detectable levels above the criterion, the chemical will be identified as a COPC. Depending on the magnitude of blank contamination and site sample COPC concentrations, a site sample COPC concentration may be adjusted accordingly. If all samples without corresponding blank contamination are nondetect, the chemical will not be identified as a COPC.

3.2 BACKGROUND

DTSC risk assessment policy indicates metals should be included as COPCs if the site-specific analytical data indicate conditions are in excess of "background" levels (DTSC 1997). The following subsections outline the methods to determine whether site data are consistent with background conditions at the subject property for purposes of selecting COPCs.

Section 3.2.1.1 provides the mathematical procedures for comparing site soil data to background and identifies samples that are candidates for inclusion in the inorganic chemical background determination.

3.2.1 Inorganic Background Determination

DTSC policy discusses the use of a simple comparison (Comparison Method) of site and inorganic chemical background data distributions and, if necessary, the use of a statistical procedure called the Wilcoxon Rank Sum Test for comparison of background and site-related data (DTSC 1997). DTSC (1997) indicates that other statistical methods may also be appropriate. In this RAWP, methods for both the Comparison Method and the Wilcoxon Rank Sum Test are presented. Both approaches make use of complete available data sets for both background and the subject property or exposure area. The use of all data is a more robust test, which minimizes both Type I and Type II errors (i.e., false negative and false positive errors).

Following DTSC guidance, a two-tiered approach will be used to evaluate subject property or exposure area (site-related) and background data sets. The first tier is a simple comparison of the site data distribution against the background data distribution. According to DTSC, the maximum site concentration is compared against a value representing the upper range of background conditions. For large background data sets, the maximum background concentration may be the most appropriate upperbound range value. For smaller data sets, an upper percentile value may be more appropriate. If the maximum site concentration does not exceed the upperbound background concentration, then the chemical is excluded as a COPC. If the maximum site concentration exceeds the upperbound background concentration, then the data sets are further evaluated by application of the Wilcoxon Rank Sum Test.

The Wilcoxon Rank Sum Test tests the null hypothesis (h_o) that background and site data are within the same distribution (i.e., the presence of a chemical at the site is due to background and is not site-related). The hypothesis is tested by analyzing the "location" of the site data within the overall distribution. The data are placed in rank order and, if the site data tend to be located toward the upper extreme of the overall distribution, there is a decreasing probability that the observations are from the same population as background data. At some specified probability level, the site data are declared to be inconsistent with background and an alternative hypothesis (h_a) is accepted that the observations suggest site-related contamination.

3.2.1.1 Mathematical Procedures

The simplest Wilcoxon Rank Sum Test uses the equation:

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$$W_{rs} = \sum R_{ns} \quad (3\text{-}1)$$

where,

W_{rs} = Wilcoxon Rank Sum statistic

R_{ns} = rank value of each member of the n_s (site-specific) population in a rank-ordered population comprised of n_s and n_b values (where n_b is the population of background samples)

W_{rs} may be used to estimate the probability (p) that n_s and n_b are from the same population by consulting statistical tables[1]. An example of this procedure is shown in the example box.

Example Application of the Wilcoxon Rank Sum Test:

- Let site-specific data be population n_s.
- Where n_s = {1, 2.5, 5, and 6 mg/kg}.
- Let background chemical data be population n_b, where n_b = {0.5, 1.5, 3 mg/kg}.
- Test the null hypothesis (h_o) that the data in n_s and n_b are all from the same population by placing all values (n_s and n_b combined) in a single group, sorted in ascending rank order.
- The test population in rank order is as follows (where values from n_s are shown in bold italic):

1	2	3	4	5	6	7
0.5	***1***	1.5	***2.5***	3	***5***	***6***

- The rank values of the smaller of the data sets, n_b population are 1, 3, and 5 and W_{rs} therefore equals 9.
- Select a probability (p) criterion for declaring the populations distinct. In this example, let the criterion be $p < 0.05$ (i.e., less than 5 chances in 100 that the two sets of values would be selected at random from a single population).
- Where $W_{rs} = 9$ for sample sizes $n_b = 3$ and $n_s = 4$, the p value is greater than 0.05. Therefore, do not reject h_o, and declare the n_s population is not different from n_b.

[1] An abbreviated W_{rs} table is available in DTSC (1997) and more comprehensive tables are available in statistical texts.

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For larger samples (n_b and n_s both greater than 10 samples), a further evaluation is possible using the equation:

$$Z_{rs} = \frac{W_{rs} - n_1(m+1)/2}{\sqrt{n_1 n_2 (m+1)/12}} \qquad (3\text{-}2)$$

where,

n_1 = number of items in the smaller data set (this may be either the number of samples in n_s or n_b)

n_2 = number of items in the larger population data set (this may be either the number of samples in n_s or n_b)

$m = n_1 + n_2$

This statistic is designated Z_{rs} because it is an approximation to the normal distribution, such that Z_{rs} may be compared to values of Z (or values of the t-distribution) to determine the probability of test populations coming from the same distribution.

It should be noted that, in the case of ties (2 or more samples having an equal value) the rank assigned to each is the average of the rank values occupied by the group. Therefore, three equal values having the second, third, and fourth positions in the rank order would each be assigned a rank value of (2+3+4)/3 = 3. Where ties exist, equation 2 must be adjusted by subtracting a quantity from the (m+1) term, as follows:

$$Z_{rs} = \frac{W_{rs} - n_1(m+1)/2}{\sqrt{\frac{n_1 n_2}{12}\left[(m+1) - \frac{\sum_j^g t_j(t_j^2 - 1)}{m(m-1)}\right]}} \qquad (3\text{-}3)$$

where,

t_j = number of items in tied group j

g = total number of groups with ties

For any permutations of the test, a critical probability (usually termed α) must be specified, below which one rejects h_o (the assumption that background and site data are

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the same), and accepts an alternative hypothesis, h_a, that the site data are site-related as opposed to background-related. An α of 0.05 will be used for evaluations of individual inorganic chemicals at the subject property. This level is suggested in the DTSC (1997) guidance and is a frequently used decision level. Selecting α=0.05 is equivalent to stating that the site data should be assumed to be site-related until there is less than 1 chance in 20 that the observed ranks of site and background data were selected from the same population.

3.2.1.2 Application of the Wilcoxon Rank Sum Test

The Wilcoxon Rank Sum Test is nonparametric, i.e., it can be performed independently of the distribution of the data sets. Therefore, it can be applied to data whether or not it fits "typical" (e.g., normal, log-normal) distributions, and also applied in cases where the underlying distribution is unresolvable due to small sample size or nonrandom sampling. This makes the Wilcoxon Rank Sum Test applicable to any of the possible data sets that may be gathered at the subject property.

The Wilcoxon Rank Sum Test may be employed with small data sets (DTSC guidance specifically notes a method for sample sets of $n = 3$ to 10). However, it is anticipated that the subject property metals background data sets will rarely have less than 20 samples. At this background sample size, the test would be able to delineate differences between background and data from a site-related data set at the $p < 0.05$ level for as few as 2 site samples. Given this ability to delineate from background, it is expected that the Wilcoxon Rank Sum Test could be used for evaluation of all exposure areas at the subject property because 2 or more samples would be taken from each exposure area. For this reason, no alternatives to the Wilcoxon Rank Sum Test are proposed at this time.

Finally, it has previously been noted that the Wilcoxon Rank Sum Test utilizes a data distribution rather than a sample parameter. Therefore, it is necessary to specify the total background data set, rather than a single specific value (e.g., central tendency, confidence bound), for comparison to site data values.

3.2.1.3 Metals Background Soil Data

A soil metals background data set will be compiled, as part of the Phase II soil investigation, from all samples collected at the subject facility property (i.e., including

samples obtained from Parcels A through D). This background dataset for the entire Former C-6 Facility property will be used in the risk assessment for Parcel D. Additional data might be added to the data set as a result of future studies. The data quality requirements and data analysis described herein would be applied to any additions to the data set.

Data rejected by the data validation process will not used for establishing background. Estimated data (estimated values or estimated reporting limits) will be used in the background data sets. All other background sample data deemed usable without qualifications for risk analysis by the validation process will be included in the background data set.

It is anticipated that the following 18 metals will be considered in the background evaluation:

- aluminum
- antimony
- arsenic
- barium
- beryllium
- cadmium
- chromium
- cobalt
- copper
- lead
- mercury
- molybdenum
- nickel
- selenium
- silver
- thallium
- vanadium
- zinc

All of the soil sample data for each inorganic chemical will be plotted in concentration order. Each data graph will be evaluated to identify the concentration at which the data diverge (i.e., the point at which the best-fit line of each of the two data sets bisects). This point of departure will be considered as the maximum background concentration. It will be compared to background values presented in the literature for southern California to further assess whether it is a reasonable estimate of the maximum background concentration. If there does not appear to be a point of departure or if the concentration associated with the apparent point of departure is lower than the literature values, additional site sample data may be required to further assess site background concentrations. If the concentration at the point of departure appears reasonable compared to the literature values, the data set below this point of departure will be the

background data set. The data above the point of departure are considered to be site-related.

In accordance with DTSC policy, frequency histograms and cumulative probability plots of the background data will be generated and included in the Phase II soil investigation report. Data will be plotted as one-half the SQL, where the metal was not detected. Data and reporting limits qualified as "estimated" by the data validator will also be included in the plots at the reported values.

Background data will be plotted both in standard numeric form and as log transformed data to determine if any pattern would emerge in terms of symmetric (normal or log-normal) distributions for purposes of deriving the appropriate background concentration for the Comparison Method.

Plotting all nondetects at one-half the SQL has the effect of making the distribution appear less variant (i.e., more sample results are similar to each other) than it may actually be if actual concentrations below the SQL are randomly distributed between zero and one-half the SQL. However, because this effect occurs at the low end of the distribution, it would not affect the ability to make background comparisons until a large number of the total results in the data set are nondetect. Any occurrence of an unusually large number on nondetect background samples will be evaluated on a case-by-case basis.

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Table 3-1 (Page 1 of 4)
LIST OF ANALYTES AND DETECTION LEVELS

No.	Required Analytes	CAS Number	CRDL for Water (µg/L)	CRDL for Soil (mg/kg)
Volatile Organics (GC/MS) by USEPA 8260B (Standard List)				
	BENZENE	71-43-2	1.00	0.005
	BROMOCHLOROMETHANE	74-97-5	1.00	0.005
	BROMODICHLOROMETHANE	75-27-4	1.00	0.005
	BROMOFORM	75-25-2	1.00	0.005
	BROMOMETHANE	74-83-9	2.00	0.010
	CARBON TETRACHLORIDE	56-23-5	0.50	0.005
	CHLOROBENZENE	108-90-7	1.00	0.005
	2-CHLOROETHYLVINYL ETHER	110-75-8	5.00	0.010
	CHLOROETHANE	75-00-3	2.00	0.010
	CHLOROFORM	67-66-3	1.00	0.005
	CHLOROMETHANE	74-87-3	2.00	0.010
	DIBROMOCHLOROMETHANE	124-48-1	1.00	0.005
	1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	2.00	0.010
	1,2-DICHLOROBENZENE	95-50-1	1.00	0.005
	1,3-DICHLOROBENZENE	541-73-1	1.00	0.005
	1,4-DICHLOROBENZENE	106-46-7	1.00	0.005
	DICHLORODIFLUOROMETHANE (Freon 12)	75-71-8	1.00	0.010
	1,1-DICHLOROETHANE	75-34-3	1.00	0.005
	1,2-DICHLOROETHANE	107-06-2	0.50	0.005
	1,1-DICHLOROETHENE	75-35-4	1.00	0.005
	CIS-1,2-DICHLOROETHENE	156-59-2	1.00	0.005
	TRANS-1,2-DICHLOROETHENE	156-60-5	1.00	0.005
	1,2-DICHLOROPROPANE	78-87-5	1.00	0.005
	CIS-1,3-DICHLOROPROPENE	10061-01-5	0.50	0.005
	TRANS-1,3-DICHLOROPROPENE	10061-02-6	0.50	0.005
	ETHYLBENZENE	100-41-4	1.00	0.005
	METHYLENE CHLORIDE	75-09-2	1.00	0.005
	1,1,2,2-TETRACHLOROETHANE	79-34-5	1.00	0.005
	TETRACHLOROETHENE (PCE)	127-18-4	1.00	0.005
	TOLUENE	108-88-3	1.00	0.005
	1,1,1-TRICHLOROETHANE	71-55-6	1.00	0.005
	1,1,2-TRICHLOROETHANE	79-00-5	1.00	0.005
	TRICHLOROETHENE (TCE)	79-01-6	1.00	0.005
	TRICHLOROFLUOROMETHANE	75-69-4	2.00	0.010
	VINYL CHLORIDE	75-01-4	0.50	0.010
	XYLENES (TOTAL)	108-38-3/95-47-6	1.00	0.005
	2,2-DICHLOROPROPANE	594-20-7	1.00	0.005
	1,1-DICHLOROPROPENE	563-58-6	1.00	0.005
	1,2-DIBROMOETHANE	106-93-4	1.00	0.005
	1,1,1,2-TETRACHLOROETHANE	630-20-6	1.00	0.005
	STYRENE	100-42-5	1.00	0.010
	ISOPROPYLBENZENE	98-82-8	1.00	0.005
	1,2,3-TRICHLOROPROPANE	96-18-4	1.00	0.005
	N-PROPYLBENZENE	103-65-1	1.00	0.005
	BROMOBENZENE	108-86-1	1.00	0.005
	2-CHLOROTOLUENE	95-49-8	1.00	0.005
	4-CHLOROTOLUENE	106-43-4	1.00	0.005
	1,3,5-TRIMETHYLBENZENE	108-67-8	1.00	0.005
	T-BUTYLBENZENE	98-06-6	1.00	0.005
	1,2,4-TRIMETHYLBENZENE	95-63-6	1.00	0.005
	SEC-BUTYLBENZENE	135-9-88	1.00	0.005
	P-ISOPROPYL TOLUENE	99-87-6	1.00	0.005
	N-BUTYLBENZENE	104-51-8	1.00	0.005
	1,2,4-TRICHLOROBENZENE	120-82-1	1.00	0.005
	HEXACHLOROBUTADIENE	87-68-3	1.00	0.005

Table 3-1 (Page 2 of 4)
LIST OF ANALYTES AND DETECTION LEVELS

No.	Required Analytes	CAS Number	CRDL for Water (µg/L)	CRDL for Soil (mg/kg)
	1,2,3-TRICHLOROBENZENE	87-61-6	1.00	0.005
	METHYL T-BUTYL ETHER (MTBE)	1634-04-4	1.00	0.005
	ACETONE	67-64-1	10.0	0.025
	ACETONITRILE	75-05-8	2.00	0.010
	ACROLEIN	107-02-8	20.0	0.10
	ACRYLONITRILE	107-13-1	20.0	0.05
	CARBON DISULFIDE	75-15-0	1.00	0.005
	2-HEXANONE	591-78-6	6.00	0.025
	IODOMETHANE	74-88-4	2.00	0.010
	2-BUTANONE(MEK)	78-93-3	5.00	0.025
	4-METHYL-2-PENTANONE(MIBK)	108-10-1	5.00	0.025
	VINYL ACETATE	108-05-4	6.00	0.010
	TETRAHYDROFURAN	109-99-9	10.0	0.020
	Volatile Organics (GC/MS) by USEPA 8260B (Standard List + 1,4-Dioxane)			
	1,4- DIOXANE	123-91-1	NA	0.25
	Volatile Organics (GC/MS) by USEPA 8260B (Standard List + Oxy) - includes Standard List and Oxygenates listed below			
	T-BUTANOL	75-65-0	25.0	0.100
	ISOPROPYL ETHER (DIPE)	108-20-3	2.0	0.010
	TERT-AMYL METHYL ETHER (TAME)	994-05-8	2.0	0.010
	TERT-BUTYL ETHYL ETHER (ETBE)	637-92-3	2.0	0.010
	Volatile Organics (GC/MS) by USEPA 8260B (Standard List + Oxy + TICs) -includes Standard List, Oxy + top 10 TICs			
	Volatile Organics (GC/MS) by USEPA 8260B (Expanded) -includes Standard List, Oxygenates, top 10 TICs + 1,4- Dioxane			
	1,4- DIOXANE	123-91-1	NA	0.250
	Semivolatile Organics (GC/MS) by USEPA 8270C			
	N-NITROSODIMETHYLAMINE	62-75-9	10.0	0.33
	PHENOL	108-95-2	10.0	0.33
	ANILINE	62-53-3	20.0	0.66
	BIS(2-CHLOROETHYL)ETHER	111-44-4	10.0	0.33
	2-CHLOROPHENOL	95-57-8	10.0	0.33
	1,3-DICHLOROBEZENE	541-73-1	10.0	0.33
	1,4-DICHLOROBENZENE	106-46-7	10.0	0.33
	1,2-DICHLOROBENZENE	95-50-1	10.0	0.33
	BENZYL ALCOHOL	100-51-6	10.0	0.33
	2-METHYLPHENOL	95-48-7	10.0	0.33
	BIS(2-CHLOROISOPROPYL)ETHER	108-60-1	10.0	0.33
	4-METHYLPHENOL	106-44-5	10.0	0.33
	N-NITROSO-DI-N-PROPYLAMINE	621-64-7	10.0	0.33
	HEXACHLOROETHANE	67-72-1	10.0	0.33
	NITROBENZENE	98-95-3	10.0	0.33
	ISOPHORONE	78-59-1	10.0	0.33
	2-NITROPHENOL	88-75-5	10.0	0.33
	2,4-DIMETHYLPHENOL	105-67-9	10.0	0.33
	BIS(2-CHLOROETHOXY)METHANE	111-91-1	10.0	0.33
	2,4-DICHLOROPHENOL	120-83-2	10.0	0.33
	BENZOIC ACID	65-85-0	50.0	1.60
	1,2,4-TRICHLOROBENZENE	120-82-1	10.0	0.33
	4-CHLOROANILINE	106-47-8	10.0	0.33

Table 3-1 (Page 3 of 4)
LIST OF ANALYTES AND DETECTION LEVELS

No.	Required Analytes	CAS Number	CRDL for Water (µg/L)	CRDL for Soil (mg/kg)
	HEXACHLOROBUTADIENE	87-68-3	10.0	0.33
	4-CHLORO-3-METHYLPHENOL	59-50-7	10.0	0.33
	2-METHYLNAPHTHALENE	91-57-6	10.0	0.33
	HEXACHLOROCYCLOPENTADIENE	77-47-4	50.0	1.60
	2,4,6-TRICHLOROPHENOL	88-06-2	10.0	0.33
	2,4,5-TRICHLOROPHENOL	95-95-4	10.0	0.33
	2-CHLORONAPHTHALENE	91-58-7	10.0	0.33
	2-NITROANILINE	88-74-4	50.0	1.60
	DIMETHYPHTHALATE	131-4-3	10.0	0.33
	2,6-DINITROTOLUENE	606-20-2	10.0	0.33
	3-NITROANILINE	99-09-2	50.0	1.60
	2,4-DINITROPHENOL	51-28-5	50.0	1.60
	4-NITROPHENOL	100-02-7	50.0	1.60
	DIBENZOFURAN	132-64-9	10.0	0.33
	2,4-DINITROTOLUENE	121-14-2	10.0	0.33
	DIETHYLPHTHALATE	84-66-2	10.0	0.33
	4-CHLOROPHENYL-PHENYL ETHER	7005-72-3	10.0	0.33
	4-NITROANILINE	100-01-6	50.0	1.60
	4,6-DINITRO-2-METHYLPHENOL	534-52-1	50.0	1.60
	N-NITROSODIPHENYLAMINE	86-30-6	10.0	0.33
	4-BROMOPHENYLPHENYL ETHER	101-55-3	10.0	0.33
	HEXACHLOROBENZENE	118-74-1	10.0	0.33
	PENTACHLOROPHENOL	87-86-5	50.0	1.60
	DI-N-BUTYLPHTHALATE	84-74-2	10.0	0.33
	BENZIDINE	92-87-5	20.0	0.66
	BUTYLBENZYLPHTHALATE	85-68-7	10.0	0.33
	3,3'-DICHLOROBENZIDINE	91-94-1	50.0	1.60
	BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	10.0	0.33
	DI-N-OCTYLPHTHALATE	117-84-0	10.0	0.33
	Semivolatile Organics (GC/MS) by USEPA 8270C Selective Ion Monitoring (SIM)			
	1,4- DIOXANE	123-91-1	1.0	NA
	Polynuclear Aromatic Hydrocarbons (HPLC) by USEPA 8310			
	ACENAPHTHENE	83-32-9	2.00	0.400
	ACENAPHTHYLENE	208-96-8	1.00	0.200
	ANTHRACENE	120-12-7	0.04	0.008
	BENZO(A)ANTHRACENE	56-55-3	0.08	0.016
	BENZO(A)PYRENE	50-32-8	0.05	0.004
	BENZO(B)FLUORANTHENE	205-99-2	0.02	0.004
	BENZO(G,H,I)PERYLENE	191-24-2	0.08	0.016
	BENZO(K)FLUORANTHENE	207-08-9	0.02	0.010
	CHRYSENE	218-01-9	0.10	0.020
	DIBENZ(A,H)ANTHRACENE	53-70-3	0.20	0.040
	FLUORANTHENE	206-44-0	0.10	0.020
	FLUORENE	86-73-7	0.20	0.040
	INDENO(1,2,3-CD)PYRENE	193-39-5	0.10	0.020
	NAPHTHALENE	91-20-3	1.00	0.200
	PHENANTHRENE	85-01-8	0.08	0.016
	PYRENE	129-00-0	0.20	0.040
	Polychlorinated Biphenyls (GC/ECD) by USEPA 8082			
	AROCLOR-1016	12674-11-2	1.00	0.033
	AROCLOR-1221	11104-28-2	1.00	0.033
	AROCLOR-1232	11141-16-5	1.00	0.033

Table 3-1 (Page 4 of 4)
LIST OF ANALYTES AND DETECTION LEVELS

No.	Required Analytes	CAS Number	CRDL for Water (µg/L)	CRDL for Soil (mg/kg)
	AROCLOR-1242	53469-21-9	1.00	0.033
	AROCLOR-1248	12672-29-6	1.00	0.033
	AROCLOR-1254	11097-69-1	1.00	0.033
	AROCLOR-1260	11096-82-5	1.00	0.033
	CCR Title 22 Metals (ICP, ICP/MS, GraphiteAA, Hydride) by USEPA 6010B/6020/7000 series or equivalent			
	ALUMINUM	7429-90-5	200.0	20.0
	ANTIMONY	7440-36-0	60.0	6.00
	ARSENIC	7440-38-2	10.0	1.00
	BARIUM	7440-39-3	20.0	2.00
	BERYLLIUM	7440-41-7	5.0	0.50
	CADMIUM	7440-43-9	5.0	0.50
	CHROMIUM	7440-47-3	10.0	1.00
	COBALT	7440-48-4	50.0	5.00
	COPPER	7440-50-8	25.0	2.50
	LEAD	7439-92-1	5.0	0.50
	MERCURY	7487-94-7	0.20	0.10
	MOLYBDENUM	7439-98-7	40.0	4.00
	NICKEL	7440-02-0	40.0	4.00
	SELENIUM	7782-49-2	5.0	0.50
	SILVER	7440-22-4	10.0	1.00
	THALLIUM	7440-28-0	10.0	1.00
	VANADIUM	7440-62-2	50.0	5.00
	ZINC	7440-66-6	20.0	2.00
	Hexavalent Chromium (Colorimetric) by USEPA 7196A			
	Cr 6+ (COLORIMETRIC) BY USEPA 7196A	18540-29-9	20.0	0.100 [5]
	Total Petroleum Hydrocarbons (GC/FID) by USEPA 8015M Extended Range			
	Total Petroleum Hydrocarbons	N/A	1000	10.0
	Perchlorate (Ion Chromatography) by USEPA 314.0			
	PERCHLORATE	14797-73-0	5.0	0.050
	Total Cyanide (Distillation) by USEPA 9010B / 9014			
	CYANIDE (TOTAL)	57-12-5	10.0	0.50
	Amenable Cyanide (Distillation) by USEPA 9012			
	CYANIDE (AMENABLE)	57-12-5	10.0	0.50

Notes:

All USEPA Methods cited are from USEPA SW-846 Method sources.

CRDL = Contract required detection limit. Also referred to as the reportable detection limit (RDL).

USEPA Method 7196A for soils uses a deionized water extraction.

Acronyms:

CAS = Chemical Abstracts Service

DI = Deionized water

GC/ECD = gas chromatography/electron captur detector

GC/FID = gas chromatography/flame ionizatio

GC/MS = gas chromatography/mass spectrophotometer

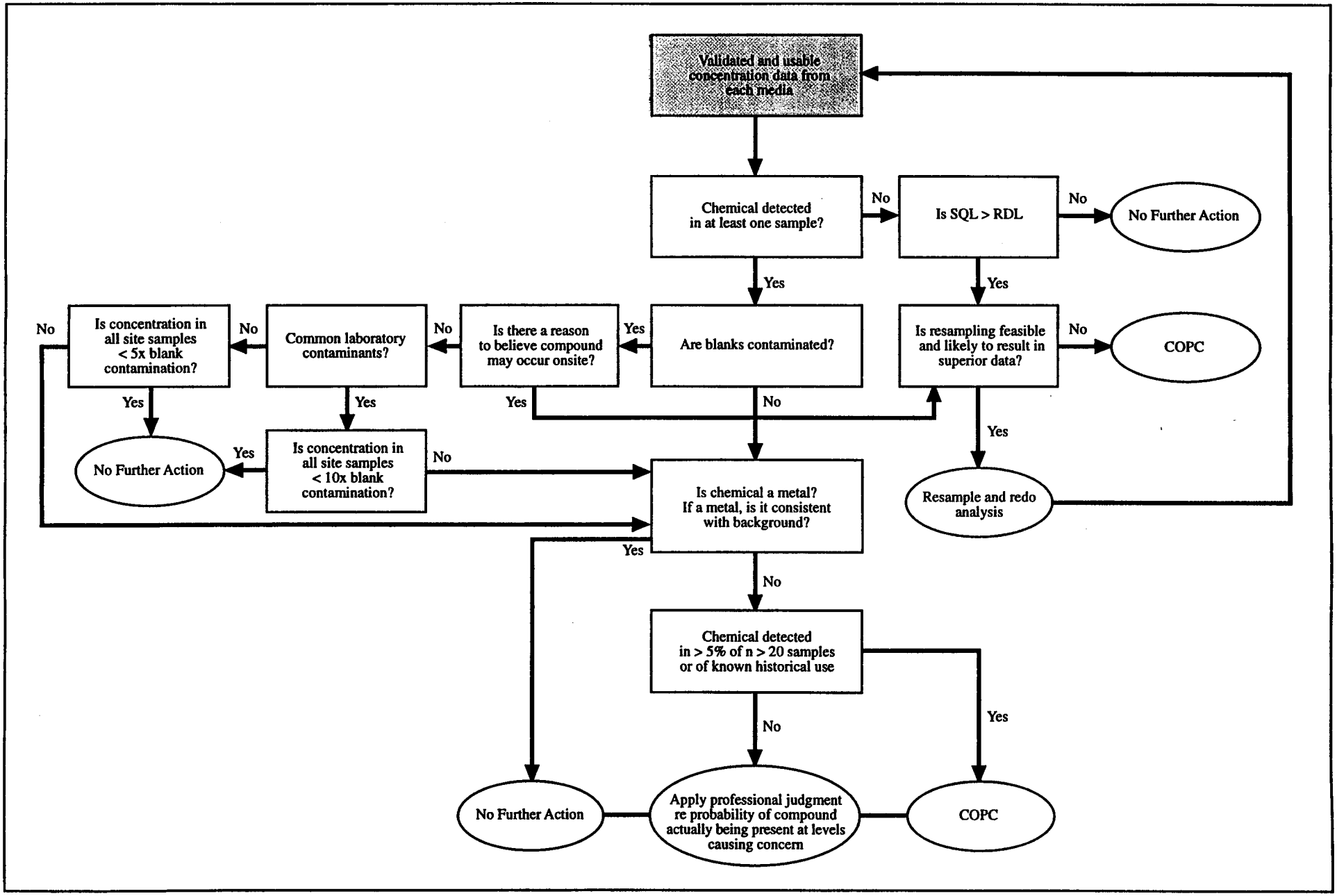
HPLC = high performance liquid chromatograp

mg/kg = milligrams per kilogram

N/A = Not applicable

TIC = tentatively identified compound

µg/L = micrograms per liter



OGDEN

Risk Assessment Identification of COPCs
BRC Former C-6 Facility
Los Angeles, California

FIGURE
3-1

Boeing/Boeing C-6/Graphics/Health Risk COPCs_6.Fh8

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SECTION 4
CONCEPTUAL SITE MODEL

A generalized conceptual site model (CSM) for the subject property has been developed based on the types of chemicals likely to be found in soils and groundwater during the investigation activities, the anticipated future uses of the subject property (including likely receptors), and the physical characteristics of the subject property. The focus of the CSM is to identify potential pathways for human exposure to chemicals currently existing in impacted soil and groundwater as well as future exposure pathways due to chemical migration.

4.1 Contaminant Characteristics and Possible Exposure Routes

Human exposure to chemical contaminants in onsite soil and groundwater is dependent, in part, on characteristics of those chemical contaminants. Specifically, the physical and chemical properties of COPCs determine how the COPC will behave in the environment and, consequently, the relevance of various possible exposure pathways and exposure routes. As presented in Section 2, the primary chemicals that will be evaluated during the Phase II investigations are VOCs, SVOCs, PAHs, polychlorinated biphenyls (PCBs), metals, and TPH.

Due to this wide range of chemical characteristics, all possible exposure routes will be considered in the development of the CSM for the subject property.

4.2 Selection of Receptors and Pathways

The following sections present the candidate receptors and exposure pathways for the subject property.

4.2.1 Receptors

Possible human receptors were identified considering future land use scenarios at the subject property. The planned primary use of the subject property following redevelopment will be light industrial and commercial use.

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Receptors were identified as those having the greatest potential for exposure during and after property redevelopment. More than one type of receptor was identified since the types of potentially complete exposure pathways and the magnitude of exposure may differ between these receptors, based on specific receptor characteristics and behaviors. Exposure parameters that may differ among receptors include body weight, skin surface area, intake rates, frequency of exposure, and duration of exposure. In addition, both onsite and offsite receptors will be evaluated. Specific exposure parameter values for the receptors identified in this section are provided in Section 7.

4.2.1.1 Receptors During Property Redevelopment Activities

The candidate receptors during property redevelopment activities are the onsite construction worker and the offsite resident or the offsite light industrial/commercial worker. Each of these receptors is described below.

Onsite Construction Worker

Construction workers will be involved in excavation activities (for foundations and utility lines, likely to depths less than 12 feet bgs), ground surface regrading, and building construction activities during property redevelopment. These construction workers may be exposed to chemicals present in onsite soil from the ground surface to a depth of 12 feet bgs. Therefore, a construction worker scenario will be evaluated in the risk assessments. Because limited site grading will be necessary, it is assumed this receptor is the general construction worker present during both site grading and construction activities.

Offsite Light Industrial/Commercial Worker or Offsite Resident (Child)

Although there is little potential for migration or transport of chemical contaminants from the subject property to offsite receptors, there is some potential for fugitive dust generated from site soils to move offsite during property redevelopment activities. Either an offsite residential child or an offsite light industrial/commercial worker will be identified as the appropriate offsite receptor during the property redevelopment activities. The selection of the appropriate receptor will be based on the prevailing wind direction across the subject property and the closest potential downwind receptor. The residential child receptor was selected as the residential receptor with the greater exposure potential, as

compared to an adult residential receptor, given their higher contact rates and lower body weights.

4.2.1.2 Receptors After Property Redevelopment

The candidate receptors after property redevelopment are the onsite light industrial/ commercial worker, the onsite gardener, and the offsite resident or light industrial/commercial worker. These receptors are described below.

Onsite Light Industrial/Commercial Worker

Under the light industrial/commercial land use scenario, which is based on the anticipated redevelopment plans for the subject property, the likely uses of the property include offices, retail, and possibly light manufacturing. No extensive or heavy manufacturing is anticipated. Although many of the buildings to be constructed during redevelopment are likely to be multi-story buildings, only human receptors located on the ground floor will be considered. These individuals would have the greatest potential exposure to VOCs in indoor air from possible upward VOC migration from impacted soil and/or groundwater into onsite structures. Thus, the light industrial/commercial worker will be an adult worker who works on the ground floor of a light industrial/commercial building.

Onsite Gardener/Landscaper

Following redevelopment, it is likely that a gardener or landscaper will maintain any vegetative or other soil covering within the common areas of the subject property. Therefore, a gardener/landscaper scenario will be evaluated in the risk assessments.

Offsite Light Industrial/Commercial Worker or Offsite Resident (Child/Adult)

Property situated in proximity to the subject property is primarily being used for light industrial/commercial uses. Properties developed for residential purposes are also located within 0.5 mile of the subject property. Offsite light industrial/commercial workers and possibly residential receptors will be assumed to be potentially exposed to VOCs from possible VOC migration from impacted groundwater, should impacted groundwater migrate offsite. The selection of the appropriate receptor (light industrial/commercial worker versus resident) will be based on which receptor is present at the closest

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downgradient offsite property. Should the contaminant plume likely reach properties containing residential receptors based on groundwater modeling results, the residential receptor will also be evaluated. For the residential receptor, both adult and child residents will be evaluated.

In summary, the plausible receptors selected for evaluation at the subject property are:

- Onsite construction worker during property redevelopment activities
- Offsite light industrial/commercial worker or offsite residential child during property redevelopment activities
- Onsite light industrial/commercial adult worker after property redevelopment
- Onsite gardener/landscaper after property redevelopment
- Offsite light industrial/commercial worker or offsite residential child and adult after property redevelopment

4.2.2 Exposure Pathways Analysis

Potential exposure pathways were considered to evaluate whether they might be "complete" (receptors can come into contact with chemicals from the subject property), "incomplete" (no exposure is possible), or "potentially complete" (exposure may occur if site conditions change). The generalized CSM for the subject property includes complete or potentially complete exposure pathways for receptors that may occur, either at certain locations, throughout the property, or possibly offsite.

Figure 4-1 is a flowchart depicting a generalized CSM for the subject property, including the contaminant sources, complete and potentially complete exposure pathways, and receptors. The CSM is further illustrated in Figure 4-2. As discussed in Section 4.2.1, the potential human receptors are future onsite and offsite adult light industrial/commercial workers, onsite construction workers, onsite gardeners/landscapers, and offsite residents. Exposure pathways were evaluated for each of these receptors as described below.

Selection of complete or potentially complete exposure pathways includes consideration of (1) the physical/chemical nature and characteristics of the selected COPCs, (2) receptors assumed to be present under future onsite land use scenarios or during construction, and (3) the physical features of the property that may promote or prevent

particular pathways. Criteria for selecting complete pathways are generically discussed in the following sections.

A number of possible exposure pathways were not considered to be complete or potentially complete for any receptor in this RAWP. These include exposure pathways associated with domestic groundwater use, surface waters, and such food sources as beef, poultry, eggs, and milk. Groundwater was not considered a plausible exposure pathway because the groundwater in the underlying Bellflower Aquitard is not considered suitable for water supply purposes. Exposure pathways associated with surface waters were not considered because there are no surface waters within the bounds of or adjacent to the subject property. Food-related pathways such as beef, poultry, eggs, and milk were not considered because the subject property is located in a heavily populated area of Los Angeles County where land sufficient to support these types of animal crops does not exist.

A description of the assumed potentially complete and complete pathways is presented below for each of the receptors.

4.2.2.1 Receptors During Property Redevelopment Activities

As previously indicated, the candidate receptors during property redevelopment activities are the onsite construction worker and the offsite resident.

Onsite Construction Worker

The onsite construction worker is an individual involved in general construction during either light industrial/commercial or residential redevelopment. Although construction workers have a substantially lower exposure duration than any of the other receptors identified, they may have greater day-to-day exposure because of the activities in which they are engaged. The construction worker is assumed to have direct contact with shallow soil (incidental ingestion and dermal contact), and may be exposed by inhalation of fugitive dusts (generated from shallow soil); therefore, these are the identified complete exposure pathways for the construction worker.

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Offsite Light Industrial/Commercial Worker or Offsite Resident (Child)

During construction activities, it is possible that impacted soil may be released offsite due to the generation of fugitive dust (generated from shallow soil). Under a long duration of fugitive dust emissions, site-related chemicals could accumulate in surface soil on offsite properties; however, given the relatively short duration for construction projects, such accumulation is negligible in terms of human exposure. Therefore, inhalation of fugitive dust by an offsite light industrial/commercial worker or offsite residential child during the construction period is the only complete exposure pathway for either of these potential receptors.

4.2.2.2 Receptors After Property Redevelopment

The candidate receptors after property redevelopment are the onsite light industrial/ commercial worker, the onsite gardener/landscaper, and the offsite light industrial/commercial worker or resident.

Onsite Light Industrial/Commercial Worker

The future onsite adult worker is an individual who works full time in a light industrial/commercial building on the subject property following redevelopment. Since current redevelopment plans indicate that soils will be covered with asphalt (parking lots), buildings, or vegetative cover, the opportunity for direct contact with soils or the generation of fugitive dust after property redevelopment is negligible. However, should VOCs be detected in soil and/or groundwater, then there is a potential for VOC vapor migration through these media into onsite buildings. Therefore, the only complete exposure pathway for the future onsite adult worker is inhalation of VOCs indoors.

Onsite Gardener/Landscaper

The future onsite gardener/landscaper is a worker involved in gardening or landscaping activities on the subject property following redevelopment. During such gardening or landscaping activities, this individual may be exposed to site soils by incidental ingestion, dermal contact, and inhalation of fugitive dusts. However, inhalation of VOCs outdoors is negligible as compared to the above-noted pathways, since there is a greater potential for VOCs to accumulate indoors than outdoors. Therefore, incidental ingestion of

shallow soil, dermal contact with shallow soil, and inhalation of fugitive dusts (generated from shallow soil) are considered the complete exposure pathways to be evaluated for this receptor.

Offsite Light Industrial/Commercial Worker or Offsite Resident (Child/Adult)

The offsite receptor is assumed to be an individual who works or lives adjacent to the subject property. Because current redevelopment plans indicate that soils will be covered with asphalt (parking lots), buildings, or vegetative cover, the opportunity for the generation and offsite dispersion of fugitive dust is negligible after property redevelopment. This individual, thus, would not be exposed to onsite soil. However, assuming that impacted groundwater may migrate offsite, this receptor could be exposed to VOCs from the possible upward migration of VOCs from impacted groundwater into a light industrial/commercial or residential structure.

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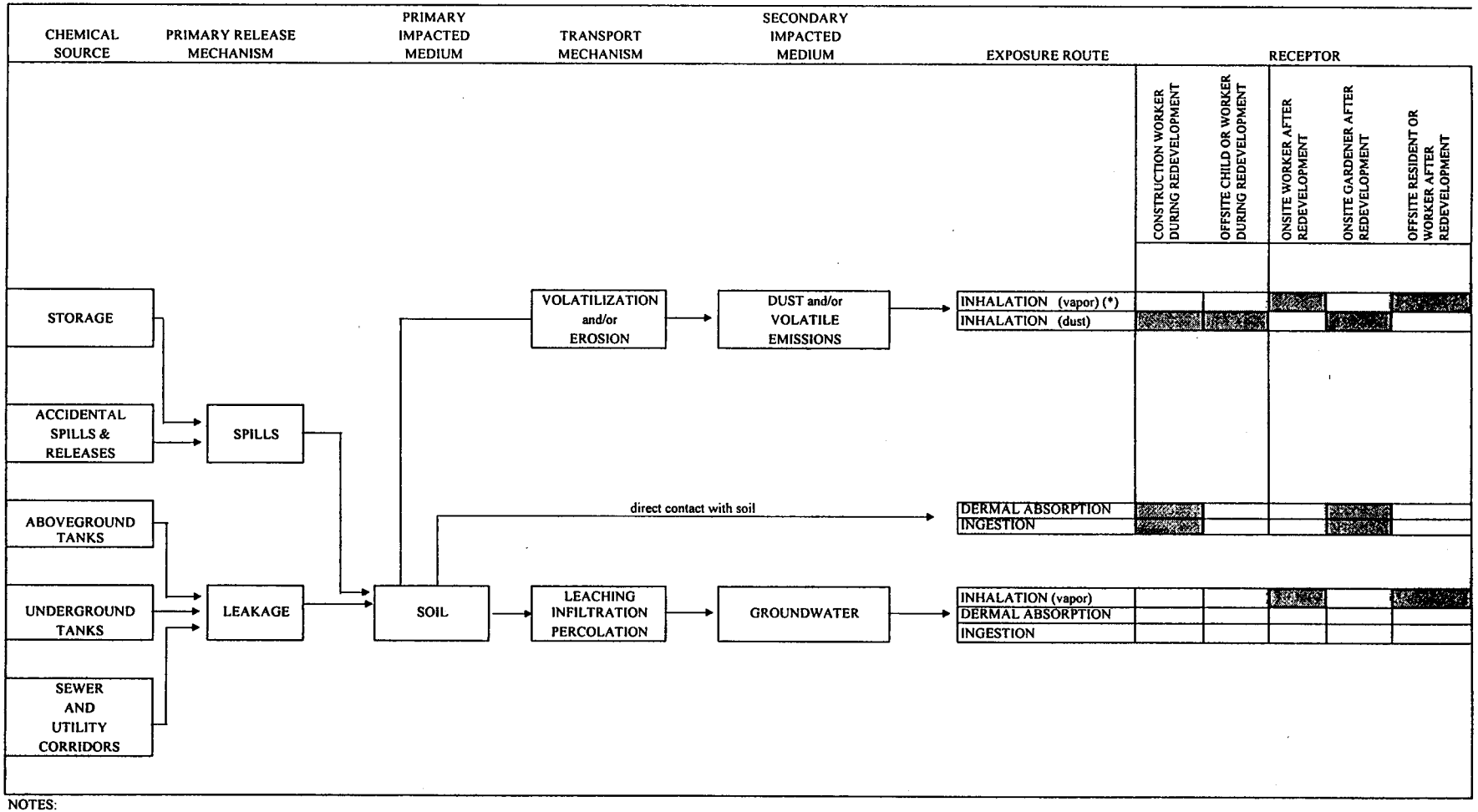
Figure 4-1. Generalized Conceptual Site Model for the Former C-6 Facility



NOTES:

(*) Exposure limited to volatile compounds as defined in the text; residential and worker receptors include only indoor air exposure to volatiles.

= Potentially complete or complete exposure pathway

= Incomplete exposure pathway

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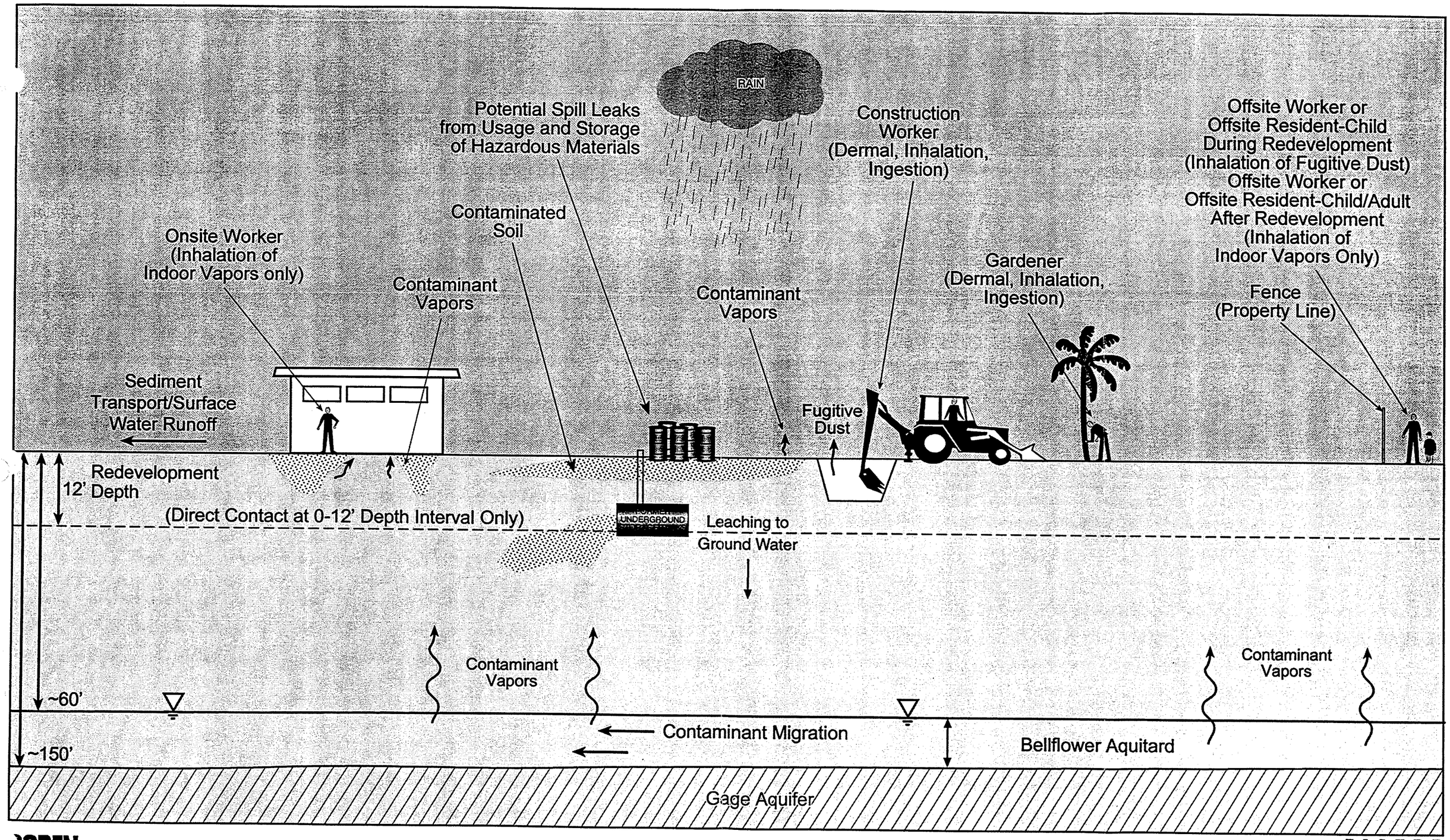

OGDEN

Illustrated Generalized Site Conceptual Model
BRC Former C-6 Facility
Los Angeles, California

FIGURE
4-2

Boeing/Boeing C-6/Graphics/Conceptual Site Model C_6.Fh8

SECTION 5
EXPOSURE POINT CONCENTRATIONS

This section presents the methodology for estimating EPCs for environmental media associated with complete and potentially complete exposure pathways at the subject property. Exposure pathways were identified in Section 4, which presented criteria for selecting possible exposure pathways and receptors following redevelopment of the subject property. Complete or potentially complete exposure pathways include direct contact with impacted soil (incidental ingestion and dermal contact), inhalation of VOCs in indoor air resulting from vapor migration from impacted soil and groundwater, and inhalation of fugitive dusts generated from site soils.

Exposure point concentrations are the concentrations of chemicals in environmental media to which a receptor may come in direct contact. Incorporation of EPCs into human intake models, as described in Section 7, allows for calculation of human exposure in terms of dose or intake. Based on the exposure pathways described in Section 4, EPCs are needed for soils, indoor VOC air concentrations, and outdoor air concentrations of fugitive dusts. Soil EPCs will be calculated from soil samples collected from the ground surface to 12 feet bgs to estimate potential intake from soil ingestion, dermal contact, and inhalation of fugitive dust. Potential intakes from inhalation of indoor air may be estimated from soil samples collected from the ground surface to 12 feet bgs, and from depths of greater than 12 feet bgs to the groundwater table. Concentrations of VOC COPCs in groundwater of the Bellflower Aquitard will also be obtained to estimate potential VOC vapor migration into indoor air. Existing groundwater data will be used to estimate potential VOC vapor migration under existing conditions. Alternatively, actual soil gas concentrations may be used to estimate indoor air concentrations resulting from potential VOC migration from subsurface soil and groundwater into buildings.

Because the migration pathway from groundwater would be through the vadose zone soil column, it is possible that combined modeling of both vapor transport from groundwater and from soil could amount to "double counting" the resulting ambient indoor air concentration. Whereas, modeling of indoor air concentrations using soil gas data provides estimated indoor air concentrations from combined soil and groundwater sources. Therefore, when soil and groundwater data (as opposed to soil gas data) are used to derive indoor air concentrations, the greatest of the calculated indoor air EPCs using either the soil or the groundwater data set will be used in the risk assessment.

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Fate and transport modeling will be used to estimate potential VOC leaching from soil to groundwater, and subsequent prediction of groundwater COPC concentrations for the estimation of potential VOC vapor migration associated with possible future groundwater impacts. Soil EPCs will be obtained by direct measurement (sampling and analysis), while indoor air VOC EPCs and outdoor air fugitive dust EPCs will be estimated using regulatory-approved fate and transport models. Such fate and transport models will use site-specific data whenever available.

Since human intake will be estimated for both typical and high-end exposures (USEPA 1992b), two different EPCs will be calculated to represent such exposures. The typical exposure EPCs for soils, indoor air VOCs, and fugitive dusts will be estimated as the arithmetic average concentration, and will be referred to as the "Typical EPC." The high-end exposure EPC will be referred to as the "reasonable maximum exposure" (RME) EPC, and will be calculated as the maximum concentration or the 95% upper confidence limit (UCL) of the arithmetic mean, whichever is lower.

For both the Typical EPC and RME EPC, the method of calculating arithmetic means and 95% UCLs will be dictated by the type of distribution that best fits the data (USEPA 1989, 1992c). Generally, the distribution will either be assumed to be a normal distribution or a log-normal distribution. The methods for determining the type of distribution and for calculating mean and 95% UCLs are described in the following section. Models for estimating indoor air VOC and outdoor air fugitive dust EPCs are described in subsequent sections.

5.1 Data Distributions and Selection of Statistical Methods

Data determined to be usable for risk assessment will be evaluated on an exposure area and chemical-specific basis to establish the type of distribution that the data best fit. USEPA (1992c) recommends both a qualitative and a quantitative approach for making this determination. Both approaches will be applied to site data.

The qualitative evaluation serves two purposes. First, it provides confirmation of the quantitative statistical evaluation. Second, data often fail the statistical tests for both normality and log normality. In the absence of statistical test results clearly identifying a

specific distribution type, the qualitative evaluation can be used to "visually" determine the distribution type (USEPA 1992c).

The quantitative statistical test used to evaluate distribution type will be D'Agostino's test of normality (Gilbert 1987). Application of D'Agostino's test to the normal data allows one to determine the probability (p) that the data are consistent with a normal distribution. Application of D'Agostino's test to the log-transformed data allows for determination of the probability (p) that the data are consistent with a log-normal distribution.

Data distributions are qualitatively evaluated by either plotting the normal data and log-transformed (natural log) data as histograms or plotting the normal data and log-transformed data in rank order. A histogram of a normally distributed data set will appear to represent an approximate Gaussian distribution (a uniform bell-shaped curve). When plotted in rank order, if the data fit a perfect normal distribution, then the normal data will be linearly related (i.e., the data will follow a straight line). If the data represent a perfect log-normal distribution, then the log-transformed data will appear as a straight line. Whichever "appears" to be more linear will be assumed to be more consistent with that distribution type.

Selection of a normal or log-normal distribution for a given chemical data set will be based on interpretation of both plotted data and statistical results. As a general rule, if the statistical results indicate that there is a 95% or greater probability (i.e., $p < 0.05$) that the data fit a particular distribution, then that distribution will be selected to represent the data set in subsequent calculations. In cases where a data set fails both the normal and log-normal tests, then consideration will be given to both the relative magnitude of p for each case and the qualitative physical "graphical" attributes of the distribution. In cases where neither statistical nor graphical interpretation of the data provides clear definition of the distribution, then the distribution type representing the more conservative EPC will be selected for estimating EPCs.

5.2 Exposure Point Concentrations for Surface and Subsurface Soil and Soil Vapor Pathways

Ingestion of and dermal absorption from soil, inhalation of fugitive dust, and VOC migration from soil to indoor air are potentially complete exposure pathways at the site.

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Data collected during field investigations at the site from the ground surface to 12 feet bgs will form the basis for soil EPCs used to estimate chemical-specific intakes for ingestion and dermal absorption from soil, and to estimate fugitive dust EPCs. Either soil or soil vapor may be used to model VOC migration from the soil column into indoor air. If soil concentrations are used, soil sample data from the entire vadose soil column (i.e., from the ground surface to the water table) will be used to estimate indoor air concentrations as described in Section 5.4.2.1.

Consistent with DTSC guidance (1992), the chemical-specific soil EPCs and/or soil vapor concentrations used to estimate the indoor air EPCs for the RME will be characterized as the lower of (1) the maximum detected concentration or (2) the 95% UCL of the arithmetic mean concentration.

As discussed in Section 5.1, the 95% UCL is calculated differently depending on:

- the nature of the data distribution, and
- spatial considerations.

5.2.1 Data Distribution Considerations

In the case of normally distributed data with no spatial component, the 95% UCL is:

$$UCL = \bar{x} + (t_{\alpha} * s/\sqrt{n-1}) \qquad (5\text{-}1)$$

where,

UCL = the specified upper confidence limit (i.e., 95%) on the estimate of the arithmetic mean
$\bar{x}$ = mean concentration
t_{α} = value of t for the specified confidence level, α
s = standard deviation of the distribution
n = number of independent analytical samples

If the data are log-normally distributed and no spatial considerations are required, the UCL (using the "H-statistic") is:

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$$UCL = e^{\bar{x} + 0.5s^2 + \frac{sH}{(n-1)^{1/2}}} \quad (5\text{-}2)$$

where,

UCL = the specified upper confidence limit (i.e., 95%) on the estimate of the arithmetic mean

$\bar{x}$ = mean of the sample distribution

s = standard deviation of the sample distribution

H = statistic accounting for interaction of the distribution developed by Land (1975)

n = number of independent analytical samples

It should be noted that USEPA (1997a) indicates that the H-statistic may overestimate the UCL, especially when the data are not actually log-normally distributed and in some cases even when it is (e.g., log-normal appearing data set where the number of samples is less than 30 [n<30]). Should the estimated EPC using the H-statistic result in risk estimates considered to be significant, alternative EPC calculation methods (e.g., bootstrapping) may be employed to provide a less conservative estimate of the UCL (USEPA 1997a).

The chemical-specific EPC for the Typical exposure will be characterized as the arithmetic mean soil concentration of the normally or log-normally distributed data set, as appropriate. As recommended in DTSC guidance (1992), one-half of the analytical reporting limit concentration will be used as a representative concentration for nondetect results for COPCs.

5.2.2 Spatial Distribution Considerations

For area-specific EPCs, DTSC (1992) and USEPA (1989) guidance will be followed. In areas where spatial sampling has adequately characterized contamination, the spatial distribution of COPCs will be evaluated to determine the appropriate method for estimating EPCs. In cases where sampling density is not consistent across an exposure area, area-weighted averaging may be applied, as recommended by DTSC (1992).

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Area-weighted averaging may be conducted in a number of ways, ranging in complexity from constructing polygons from lines drawn equidistant between sampling locations (Thiessen polygons) (Clifford et al. 1995) to establishing unbiased estimates of concentration and variance change with distance and using the results to construct a spatial grid of estimated concentrations (ordinary kriging) (Isaaks and Srivastava 1989). The latter is data intensive and unlikely to be feasible for many of the exposure areas at the subject property. Therefore, the Thiessen polygon approach is proposed.

To construct Thiessen polygons, a perpendicular line is drawn equidistant between sampling points. For samples surrounded by other sampling points, the polygon is created where the set of lines meet. The outermost samples are truncated at a defined boundary, such as the border of the subject property or exposure area. It is assumed that the concentration observed at the sampling point within each polygon is the best representation of concentrations within the entire area of that polygon.

Figures 5-1 and 5-2 illustrate this procedure for a data set of soil concentrations. In Figure 5-1, polygons have been created by using a geographic information system (GIS), which also calculates the area included in each space. Hypothetical data are shown in Figure 5-2. The hypothetical COPC concentration and area associated with each polygon is shown in Table 5-1. Table 5-1 also includes the estimated mean and 95% UCL of the unweighted and weighted data for comparison.

The area-weighted concentration is calculated using the following formula (Isaaks and Srivastava 1989):

$$\overline{x}_{sc} = \sum_{i=1}^{n} p_i c_i \qquad (5\text{-}3)$$

where,

$\overline{x}_{sc}$ = area-weighted mean concentration (e.g., milligrams per kilogram [mg/kg])

c_i = concentration representing the condition within polygon, i, where there are $i = 1$ through n polygons

p_i = proportion of the total area that is incorporated in polygon i (unitless)

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It is also possible to calculate the variance of area-weighted samples using the formula (Isaaks and Srivastava 1989):

$$s_{sc}^2 = \sum_{i=1}^{n} p_i c_i^2 - \left(\sum_{i=1}^{n} p_i c_i\right)^2 \qquad (5\text{-}4)$$

where,

s_{sc}^2 = variance of the distribution (e.g., mg^2/kg^2) of area-weighted sample and all other parameters are as described above

c_i = concentration representing the condition within polygon, *i*, where there are $i = 1$ through n polygons

p_i = proportion of the total area that is incorporated in polygon *i* (unitless)

Under the assumption that the concentration data may be modeled as a t-distribution, a confidence limit on the estimated area-weighted mean may be calculated (using an equation similar to that presented in Equation 5-1) as:

$$UCL = \overline{x}_{sc} + (t_\alpha * s_{sc} / \sqrt{n-1}) \qquad (5\text{-}5)$$

where,

UCL = the specified upper confidence limit (i.e., 95%) on the estimate of the mean

t_α = value of t for a specified confidence level, α

$\overline{x}_{sc}$ = area-weighted mean estimator of the mean (μ)

s_{sc} = sample standard deviation , which is the square root of the sample variance (s^2)

n = number of polygons used to estimate the distribution

It is typical to calculate the 95% UCL, for which the appropriate value of t would be calculated at $\alpha = 0.1$ for a two-tailed distribution.

The size of the polygons also strongly influences the outcome. In Example 1, as presented in Table 5-1, the weighted mean and 95% UCL are greater than the unweighted

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statistics, because the higher observed concentrations are associated with polygons of larger area. If the reverse were true (i.e., high concentrations associated with small polygons — a condition that frequently exists when "hot spots" [areas of known impacts] are intensively sampled relative to other areas of an investigation unit) as shown in Table 5-2, area-weighted means and UCLs would be lower than statistics calculated ignoring spatial dependence. The only difference between those data presented in Table 5-1 and Table 5-2 is that the hypothetical concentrations for SS-2 and SS-17 have been transposed, such that in Table 5-2 the highest concentration is now associated with a small polygon, and a low concentration is applied to a larger polygon.

Where area-weighted data do not appear to be log-normally distributed, UCLs may be calculated by "bootstrapping" a distribution of means as described in USEPA (1997a). In the case of area-weighted data, bootstrapping can be conducted in which the relative frequency of bootstrap sampling any given point is determined by the relative area associated with the polygon of the sample.

5.3 Exposure Point Concentrations for Groundwater Pathway

The concentrations of VOCs in groundwater are necessary for estimating indoor air EPCs to assess potential vapor migration of VOCs from groundwater within the Bellflower Aquitard to indoor air. This groundwater is the uppermost saturated unit beneath the subject property. As previously described in Section 4, COPCs in soil may leach to groundwater and, once present in groundwater, may migrate within the groundwater matrix to offsite locations or to other exposure areas within the subject property. At either onsite or offsite locations, VOCs in groundwater may then volatilize into the unsaturated soil pore space and migrate upward to the ground surface and into buildings. Since the groundwater in the Bellflower Aquitard is not considered suitable for water supply purposes, the primary exposure pathway associated with groundwater is potential migration of VOCs into buildings. As such, only VOCs, as defined by DTSC, will be modeled for assessing potential groundwater impacts.

Since portions of the Bellflower Aquitard are known to be contaminated from numerous sources in the region, two approaches will be taken to characterize groundwater VOC concentrations for this aquifer:

(1) Groundwater VOC data will be collected and evaluated for the purpose of estimating groundwater VOC concentrations under current conditions, and

(2) fate and transport models will be applied to soil concentration data for the purpose of assessing potential impacts to groundwater from leaching of soil VOCs. In addition, fate and transport models will be used to estimate VOC concentrations in groundwater at an onsite and/or offsite point of compliance.

Therefore, the following data will be used to estimate groundwater concentrations in the uppermost saturated zone:

- Measured groundwater VOC concentrations beneath and adjacent to the subject property
- Measured groundwater VOC concentrations downgradient at designated point(s) of compliance (based on exposure pathway analysis)
- Modeled concentrations directly below exposure areas, using exposure area-specific groundwater data (if groundwater is impacted) and soil data by application of a leaching model (to assess potential future threat to groundwater due to leaching COPCs through the soil column)
- Modeled downgradient concentrations, using measured groundwater data and leaching model results, and application of appropriate attenuation and mass transport models

5.3.1 Measured Exposure Point Concentrations for Groundwater Pathway

Groundwater VOC concentration data within the Bellflower Aquitard will be collected during the Phase II groundwater investigation. Groundwater VOC data will be subjected to the same data usability and COPC selection requirements as those used for soils, as described in Section 3. The initial existing groundwater concentrations may be assumed to be the maximum measured concentrations or may be derived using the same approach as that described for soil EPCs in Sections 5.1 and 5.2. A simple, one- or two-dimensional analytical model will be used to model contaminant transport in groundwater to a potential downgradient receptor.

5.3.2 Modeled Exposure Point Concentrations for Groundwater Pathway

Since the concentrations of VOCs in groundwater are not in equilibrium (i.e., concentrations change over time), the maximum modeled VOC concentrations over the assumed exposure period at the point of compliance may be selected to conservatively estimate indoor air EPCs, or time-weighted VOC groundwater concentrations may be calculated over the assumed exposure period to estimate indoor air EPCs during that same exposure period.

The modeling of soil VOC impacts to groundwater of the Bellflower Aquitard will be performed in the following steps:

- Leaching from soil to groundwater – these modeling results will be used to estimate VOC concentrations in groundwater underlying the subject property/exposure areas.
- Attenuation and Mass Transport – these modeling results will be used together with mass transport modeling results to estimate downgradient VOC concentration in groundwater.

Version 2.2 of the USEPA VLEACH model (USEPA 1997), a one-dimensional finite difference vadose zone leaching model, will be used to estimate the liquid phase VOC concentration at the groundwater table. Then, a mass transport model, such as a simple one- or two-dimensional analytical model, will be used to model contaminant transport in groundwater to a potential downgradient receptor.

VLEACH is typically recommended for making preliminary assessments of the effects on groundwater from the leaching of volatile, sorbed contaminants through the vadose zone. The program models the following four processes: liquid-phase advection, solid-phase sorption, vapor-phase diffusion, and three-phase equilibration. VLEACH can be used to simulate leaching in a number of distinct polygons, which may differ in terms of soil properties, recharge rates, depth of water, or initial conditions. This modeling results in an overall, area-weighted assessment of groundwater impact. Site-specific input parameters will be used as available. Conservative default parameters will be used in lieu of site-specific information.

5.4 EXPOSURE POINT CONCENTRATIONS FOR AIR PATHWAYS

Inhalation of chemicals in air represents a potentially complete exposure pathway at the subject property. Measured concentrations of COPCs in air at the subject property are not available. Furthermore, when direct air sampling is used in a risk assessment, significant background air sampling data are necessary to characterize site-related chemical concentrations in air. As such, EPCs in air will be modeled, assuming that volatile chemicals in soil and groundwater may migrate toward the ground surface and into buildings, and particulate-bound chemicals in soil may be present in air as a result of fugitive dust emissions. Methods for estimating EPCs in air as a result of volatilization and fugitive dust emissions are described in the following sections.

5.4.1 Fugitive Dust Emissions

Fugitive dust may be resuspended to air from surface soils in uncovered areas of the subject property (i.e., areas not covered by buildings, pavement, or vegetation). As an initial conservative evaluation of EPCs for particulates in air, the particulate emission factor (PEF), recommended as the basis of a default value for particulate EPCs (USEPA 1996b), will be initially applied. The PEF relates the concentration of a chemical in soil with the concentration as suspended particulates in air. USEPA has updated the PEF equation since 1993, which was the basis of the DTSC *Preliminary Endangerment Assessment (PEA) Manual*'s default equation (DTSC 1994). A detailed discussion of USEPA's rationale for correcting the PEF equation is provided in USEPA (1996b, Section 2.4.5, p. 31-32).

The current USEPA default PEF equation is as follows:

$$PEF = \frac{LS \times V \times DH \times 3{,}600\,\text{sec/}hour}{A} \times \frac{1{,}000\,\text{g/kg}}{0.036 \times (1\text{-}G) \times \left(\frac{U_m}{U_t}\right)^3 \times F(x)} \qquad (5\text{-}6)$$

where,

PEF = particulate emission factor (cubic meters per kilogram [m^3/kg])
LS = width of contaminated area (m, exposure area-specific)
V = wind speed in the mixing zone (meters per second [m/s], site-specific)[1]
DH = mixing height (m, site-specific)
A = area of contamination (m^2, site-specific)

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G = fraction of vegetative cover (0.5, unitless)

0.036 = respirable fraction (grams per square meter per hour [g/m^2-hr], USEPA default)

U_m = annual wind speed (m/s, site-specific)[1]

U_t = equivalent threshold of wind speed at 7 m (11.32 m/s, USEPA default)[2]

$F(x)$ = function dependent on U_m/U_t (0.194 unitless, USEPA default)

Using soil concentrations and the estimated PEF, air COPC concentrations are calculated as follows:

$$Ca = \frac{Cs}{PEF} \qquad (5\text{-}7)$$

where,

Ca = concentration of COPC in air (milligrams per cubic meter [mg/m^3])

Cs = concentration of COPC in soil (mg/kg)

PEF = particulate emission factor (cubic meters per kilogram [m^3/kg])

5.4.2 Volatilization of VOCs to Indoor Air

The migration of VOCs from soils to indoor air will be estimated using a simplified vapor pathway model developed for southern California by the County of San Diego (SDC 2000). The model assumes that vapors will migrate vertically by diffusion from subsurface soil through the building foundation. The source soil is assumed to be continuous (i.e., does not reduce in concentration over time), and the air exchange rate within the building is assumed to be typical of commercial and residential buildings, as applicable.

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[1] Based on mean annual wind speed measurement data available from the closest National Weather Service climatic monitoring station.

[2] The equivalent threshold value of wind speed (U_t) at 7 m of 11.32 m/s is the USEPA (1985) default value based on a soil aggregate size distribution of approximately 0.9 millimeter (mm). A site-specific U_t may be calculated for individual units in cases where surficial soil characteristics indicate that use of the USEPA default value would overestimate exposure. Unit-specific soil grain size data collected at the subject site would then be used to calculate U_t and F(x) following USEPA (1985) guidance.

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The model may be executed using either soil, soil gas, or groundwater concentrations. The model will be applied to both Typical and RME soil and/or soil vapor, and groundwater concentrations, with the results used in Section 7 to estimate human intake associated with possible exposure to VOCs in indoor air.

The indoor air vapor migration model is described below.

$$C_i\ (mg/m^3) = Slab \times F \times A \times A_c / V \times E \qquad (5\text{-}8)$$

Where:

C_i	=	VOC concentration in air (mg/m^3)
$Slab$	=	slab attenuation factor (unitless)
F	=	VOC vapor flux (milligrams per hour per square meter [$mg/hr\text{-}m^2$])
A	=	room floor area (m^2)
A_c	=	portion of floor area overlying the contaminated area (unitless)
V	=	room volume (m^3)
E	=	indoor air exchange rate per hour (hr^{-1})

The vapor flux, F, is calculated from Fick's First Law, as follows:

$$F = D_e \times Csg / X \qquad (5\text{-}9)$$

Where:

F	=	VOC vapor flux ($mg/hr\text{-}m^2$)
D_e	=	effective diffusion coefficient for the VOC (square meter per hour [m^2/hr])
Csg	=	soil gas concentration (mg/m^3)
X	=	depth to contamination in vadose zone (m)

The effective diffusion coefficient was calculated as follows:

$$D_e = D_a \times P_a^{3.33} / P_t^2 \qquad (5\text{-}10)$$

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Where:

D_e = effective diffusion coefficient for the VOC (m^2/hr)
D_a = diffusion coefficient of the VOC in air (m^2/hr)
P_a = air-filled porosity of onsite soil (fraction by volume)
P_t = total porosity of onsite soil (fraction by volume)

The San Diego County vapor migration model described above may be applied using either soil gas, soil concentration, or groundwater concentration data. Measured soil gas concentrations can be used, or soil gas concentrations may be estimated from soil and/or groundwater concentration data. Once the VOC has partitioned from either soil or groundwater into the soil gas phase, the modeling of VOC soil gas migration to indoor air concentrations is identical.

Samples from all three media (soil, soil gas, and groundwater) will be obtained at the majority of the VOC source areas. In these cases, the soil gas COPC concentrations will be compared to the reported COPC concentrations for soil and groundwater. Indoor air concentrations may be estimated using either soil and groundwater concentrations, or soil gas concentrations, whichever data appear to be the most representative of site conditions. The medium data set determined to be most representative of site conditions will be based on an evaluation of sample size, spatial distribution, sample depth, and detection limits. For instance, regarding detection limits, if vinyl chloride is detected in soil gas but not in soil, then the vinyl chloride concentration in the soil gas sample may be used to estimate the indoor EPC for vinyl chloride. Indoor air concentrations may also be estimated using data from soil and groundwater data to estimate the contribution of indoor air that may be attributed to migration from impacted soil versus impacted groundwater.

The equations used to calculate the soil gas concentration, Csg, from soil and groundwater data are presented in the following sections.

5.4.2.1 Calculation of Soil Gas Concentration from Soil Data

Using soil concentration data, the concentration of each VOC in soil gas is calculated as follows, based on equilibrium partitioning between soil, moisture, and vapor phases:

$$Csg = (H' \times Cs \times Db \times 1{,}000\ g/kg) / (P_w + (K_d \times D_b) + (H \times Pa) \quad (5\text{-}11)$$

Where:

Csg	=	VOC concentration in soil gas (mg/m^3)
H'	=	Henry's Law Constant (unitless)
Cs	=	VOC concentration in soil (mg/kg)
D_b	=	average dry soil bulk density (gm/cm^3)
P_w	=	water-filled porosity of onsite soil (fraction by volume)
K_d	=	sorption coefficient (cm^3/g), $(K_{oc} \times f_{oc}) + (K_{oi} \times f_{oi})$, where:
K_{oc}	=	sorption coefficient normalized for organic carbon (cubic centimeters per gram [cm^3/g])
f_{oc}	=	weight fraction of organic carbon in soil (unitless)
K_{oi}	=	sorption coefficient in the organic phase (cm^3/g])
f_{oi}	=	weight fraction of clay content (unitless)
P_a	=	air-filled porosity of onsite soil (fraction by volume)

5.4.2.2 Calculation of Soil Gas Concentration from Groundwater Data

Using groundwater concentration data, the concentration of each VOC in soil gas is calculated as follows, based on equilibrium partitioning between groundwater and vapor phases:

$$Csg = H' \times Cw \quad (5\text{-}12)$$

Where:

Csg	=	concentration of soil gas (mg/m^3)
H'	=	Henry's Law Constant (unitless)
Cw	=	VOC concentration in groundwater (micrograms per liter [µg/L])

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Table 5-1
EXAMPLE 1 OF AREA-WEIGHTED STATISTICS*

Site ID (sample identification relevant to those shown in Figure 6-1)	COPC Concentration (C_i; mg/kg)	Area (square feet)	Proportion of Total Area (P_i)	$P_i \times C_i^2$	Weighted Concentration (mg/kg)
SS-1	11.00	4,829	0.03	3.12	0.28
SS-2	3.00	969	0.01	0.05	0.02
SS-3	20.00	7,968	0.04	17.04	0.85
SS-4	2.00	5,643	0.03	0.12	0.06
SS-5	5.00	9,116	0.05	1.22	0.24
SS-6	8.00	7,985	0.04	2.73	0.34
SS-7	15.00	5,120	0.03	6.16	0.41
SS-8	5.00	18,870	0.10	2.52	0.50
SS-9	2.00	6,357	0.03	0.14	0.07
SS-10	2.00	12,544	0.07	0.27	0.13
SS-11	58.00	8,543	0.05	153.70	2.65
SS-12	330.00	15,709	0.08	9,148.62	27.72
SS-13	120.00	16,645	0.09	1,281.82	10.68
SS-14	11.00	19,918	0.11	12.89	1.17
SS-15	130.00	15,124	0.08	1,366.91	10.51
SS-16	2.00	16,984	0.09	0.36	0.18
SS-17	1,600.00	14,668	0.08	200,812.50	125.51
sum		186,993		212,810	181
sample number (n)	17				17
mean	137				
area-weighted mean					181
standard deviation (SD)	375				
area-weighted SD					424
standard error of the mean (SEM)	94				
area-weighted SEM					103
t 0.95 (two-tailed, 16 degrees of freedom)	1.76				1.76
95% UCL	302				362

*Area-weighted data graphically shown on Figure 5-2.

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Table 5-2
EXAMPLE 2 OF AREA-WEIGHTED STATISTICS

Site ID	COPC Concentration (C_i; mg/kg)	Area (square feet)	Proportion of Total Area (P_i)	$P_i \times C_i^2$	Weighted Concentration (mg/kg)
SS-1	11.00	4,829	0.03	3.12	0.28
SS-17	1,600.00	969	0.01	13,263.08	8.29
SS-3	20.00	7,968	0.04	17.04	0.85
SS-4	2.00	5,643	0.03	0.12	0.06
SS-5	5.00	9,116	0.05	1.22	0.24
SS-6	8.00	7,985	0.04	2.73	0.34
SS-7	15.00	5,120	0.03	6.16	0.41
SS-8	5.00	18,870	0.10	2.52	0.50
SS-9	2.00	6,357	0.03	0.14	0.07
SS-10	2.00	12,544	0.07	0.27	0.13
SS-11	58.00	8,543	0.05	153.70	2.65
SS-12	330.00	15,709	0.08	9,148.62	27.72
SS-13	120.00	16,645	0.09	1,281.82	10.68
SS-14	11.00	19,918	0.11	12.89	1.17
SS-15	130.00	15,124	0.08	1,366.91	10.51
SS-16	2.00	16,984	0.09	0.36	0.18
SS-2	3.00	14,668	0.08	0.71	0.24
sum		186,993		25,261	64
sample number (n)	17				17
mean	137				
area-weighted mean					64
standard deviation (SD)	375				
area-weighted SD					145
standard error of the mean (SEM)	94				
area-weighted SEM					35
t 0.95 (two-tailed, 16 degrees of freedom)	1.76				1.76
95% UCL	302				126

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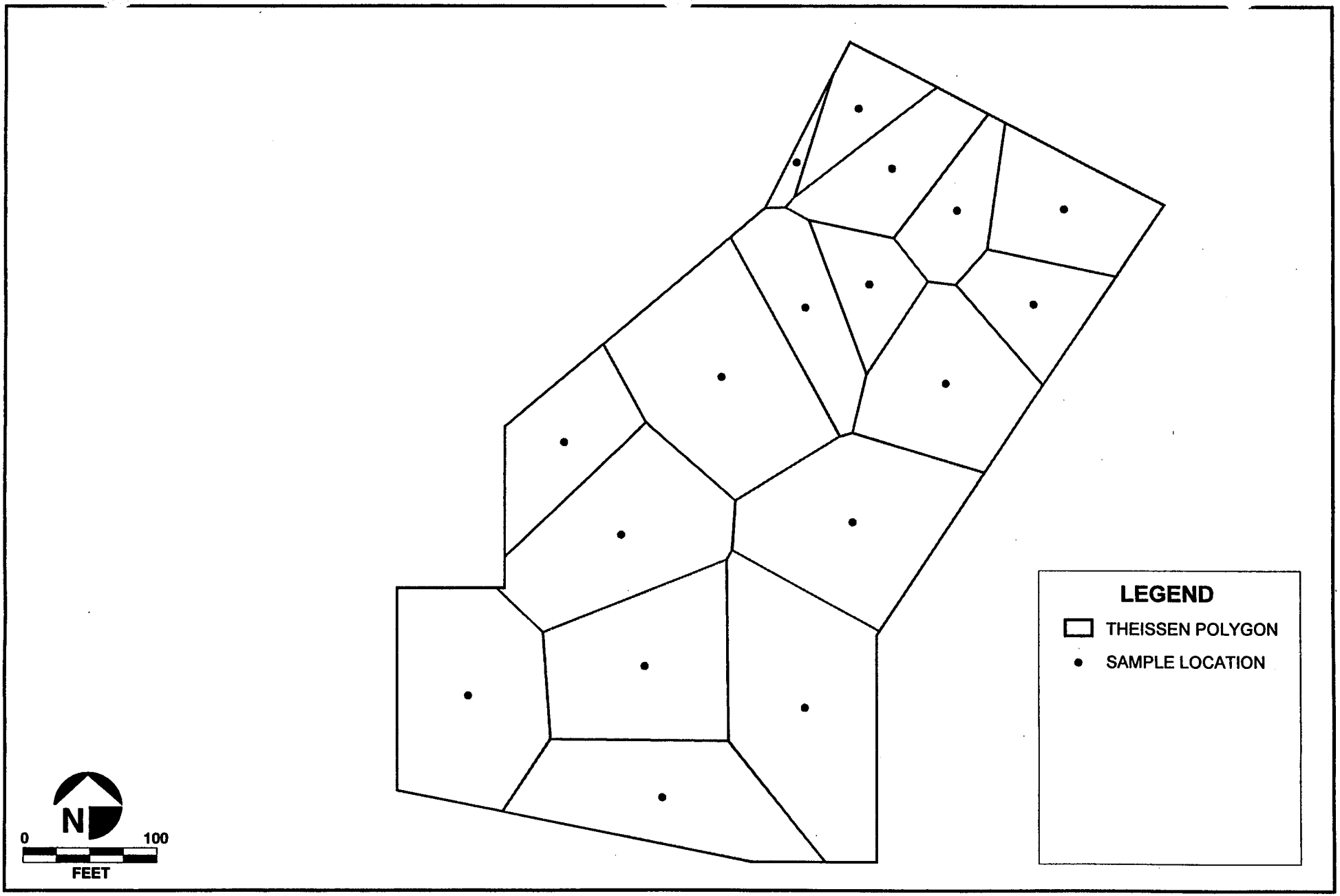

OGDEN

Example Thiessen Polygons for Surface Soil Sampling Locations
BRC Former C-6 Facility
Los Angeles, California

FIGURE
5-1

Boeing/Boeing C-6/Graphics/Fig 5_1.fh8

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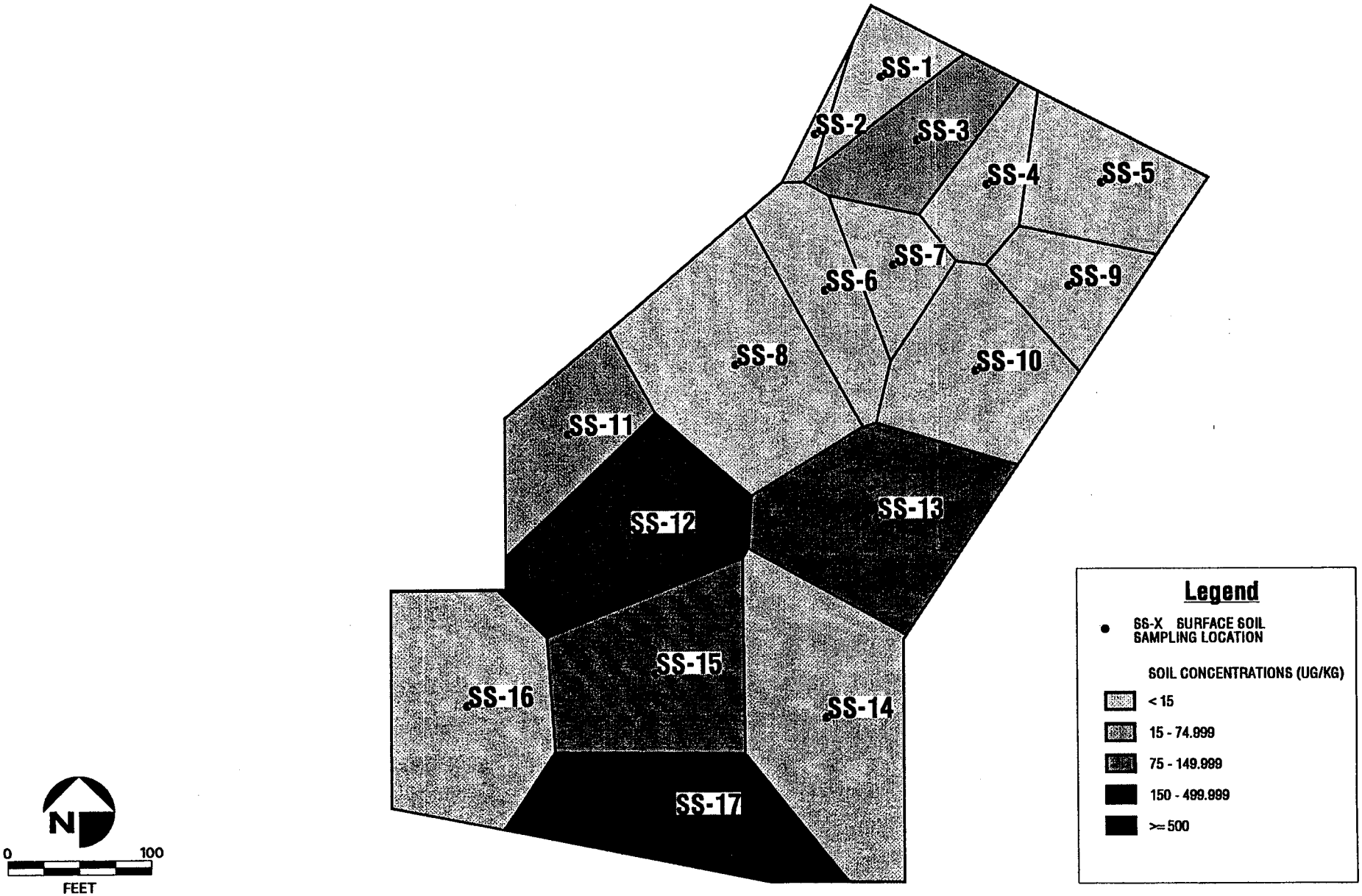

OGDEN

Hypothetical Surface Soil Sample Data for Table 5-1 Data
BRC Former C-6 Facility
Los Angeles, California

FIGURE
5-2

Boeing/Boeing C-6/Graphics/Fig 5_2.fh8

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SECTION 6
SCREENING LEVEL RISK ASSESSMENT

This section presents the methodology for a screening level risk assessment or preliminary risk evaluation (PRE) approach to be used to provide a conservative indication of potential risk to human health from exposure to site-related COPCs in soil and groundwater. The purpose of the PRE is to identify exposure areas that do not warrant further investigation or remedial action (i.e., exposure areas that clearly do not pose a significant health risk). Areas of the subject property that do not pose a significant health risk based on the PRE results will not require remediation and will not be evaluated in the risk assessment. Areas that potentially pose a significant health risk based on the PRE results will be further evaluated in the risk assessment (as described in Sections 7 through 10).

Based on the USEPA *Risk Assessment Guidance for Superfund [RAGS]: Volume I - Human Health Evaluation Manual (Part B)* (USEPA 1991a), the human health PRE typically consists of the following elements:

- Evaluation and selection of data for identification of COPCs for each exposure area, as described in Section 3

- Qualitative identification of representative receptors of concern and complete or potentially complete exposure areas pathways based on the CSM for each exposure area, as discussed in Section 4

- Calculation of EPCs within each exposure area, as described in Section 5

- Quantitative PRE by a comparison of RME concentrations for all detected chemicals for each exposure area against USEPA Region IX industrial and residential preliminary remediation goals (PRGs) that are adjusted using the California toxicity values, where available, as presented in Section 8

- Evaluation of cumulative carcinogenic risks and noncarcinogenic hazards against the risk decision criteria presented in Section 9

6.1 PRELIMINARY REMEDIATION GOAL SCREEN

The health risks estimated in each PRE will be based on the PRGs developed by USEPA Region IX and presented in *USEPA Region IX Preliminary Remediation Goals,* dated October 1, 1999 (USEPA 1999b). The concept of the PRG was formally introduced in *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B: Development of Risk-Based Preliminary Remediation Goals)* (USEPA 1991a). According to USEPA (USEPA 1991a), PRGs are health-based concentrations in environmental media that are intended by USEPA to be used to facilitate development of a range of appropriate remedial alternatives (including "no further action") and to focus selection on the most effective remedy, if any.

Within USEPA Region IX, the approach to the calculation of PRGs has been refined, and the values are published annually (USEPA 1999b). The cited guidance notes that "PRGs combine updated USEPA toxicity values with health-protective exposure assumptions to estimate contaminant levels in environmental media that correspond to a lifetime cancer risk of 10^{-6} risk and/or a hazard index (HI) of 1 for noncancer concerns." USEPA Region IX also states that PRGs can be "...used for general screening purposes, as 'triggers' for further investigation at CERCLA/Resource Conservation and Recovery Act (RCRA) sites, and as initial cleanup goals if applicable" (USEPA 1999b). Because PRGs are based on USEPA toxicity values, the PRGs will be adjusted using Cal-EPA toxicity values, when available. In cases where Cal-EPA has not adopted a cancer or noncancer toxicity value, no change will be made. Section 8 describes the priority for selecting toxicity values and presents the toxicity values used for adjusting the PRGs.

By definition, soil PRG values represent the soil concentrations below which no significant adverse health effects are likely to occur from the assumed direct contact pathways (soil ingestion, dermal contact with soil, and inhalation of fugitive dust, and inhalation of VOCs from soil). Thus, the soil PRGs derived by USEPA Region IX are typically applicable only to surface soil. When USEPA Region IX soil PRGs are applied to subsurface soil, they may be too conservative for semivolatile, immobile, or insoluble contaminants in the unsaturated zone where direct contact is unlikely. It should be noted that USEPA Region IX PRGs for some VOCs in soils may not be totally health-based. For example, when the estimated health-based PRGs were above the estimated saturation levels for VOCs in soils, referred to as C_{sat}, the lower C_{sat} levels were selected by USEPA Region IX as the final PRGs. Also, when the estimated health-based PRGs for SVOCs

and inorganics were above 100,000 mg/kg, a cutoff level of 100,000 mg/kg was selected to be the final PRG. Nevertheless, those PRGs that are based on thresholds or saturation limits are considered health-protective. Both the PRGs adjusted using California toxicity information and those that were not adjusted (i.e., USEPA PRGs) because California toxicity information is not available are presented in Table 6-1.

USEPA Region IX PRGs do not account for potential exposures from inhalation of indoor air. Thus, in addition to using USEPA Region IX PRGs to estimate incremental cumulative cancer risks and noncancer HIs, the simplified vapor pathway model developed by the County of San Diego (presented in Section 5) will be used to assess potential risk from the indoor air pathway. Using the PRE methodology, potential incremental cumulative cancer risks and noncancer HIs will be calculated for each chemical identified as a COPC (Section 3) within each exposure area. Risk estimates and HIs associated with the indoor air pathway will be added, as applicable, to risk estimates and HIs calculated using the PRG screening approach.

For chemicals where the PRGs are set at C_{sat} (VOCs) or an arbitrary ceiling concentration of 100,000 mg/kg (SVOCs and metals), a footnote in the risk calculation table will be included. Cumulative health risk calculations using these substituted PRGs will tend to overestimate the overall risks.

6.2 Quantitative Human Health Preliminary Risk Evaluation

This section presents the methodology to be used for calculation of potential carcinogenic risks and noncancer hazard indices at each exposure area. Using the CSM methodology described in Section 4, exposure pathways of concern and site conditions will be evaluated at each exposure area to ensure that the site conditions match the PRG framework. In developing the site-specific CSM, contaminant exposure areas, exposure pathways, and potential receptors will be considered.

Using a quantitative PRE to estimate the cumulative risks due to exposure to multiple chemicals via multiple exposure pathways is based on USEPA's RME scenario, defined as the maximum exposure that is reasonably expected to occur (USEPA 1989). For screening purposes, this evaluation will use the RME EPC for each COPC. Exposure area-specific cumulative excess carcinogenic risk and cumulative noncarcinogenic HI will be estimated. HIs will not be calculated for lead since, according to USEPA

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Region IX, risk calculations based on lead PRGs do not accurately reflect the risk because discernible thresholds have not been established.

According to USEPA (1991a), a site does not appear to pose a significant risk to human health if (1) the site-specific cumulative excess carcinogenic risk is equal to or less than one in one million (1×10^{-6}) and (2) the site-specific cumulative HI is equal to or less than 1. In this case, no further action will be recommended for the exposure area. If the cumulative cancer risk exceeds 1×10^{-6} or the cumulative HI exceeds 1, then site-specific risks will be assessed following the methods described in Sections 7 through 10.

6.3 Preliminary Risk Evaluation Methodology

Assuming that the effects posed by different COPCs are additive (no synergistic or antagonistic interactions) and that COPC concentrations and other exposure parameters stay constant throughout the exposure period (USEPA 1989), the cumulative RME incremental cancer risks (CR) will be conservatively calculated using the following equation:

$$CR = \sum \left[TR \, x \frac{C_i}{PRG_i} \right] \qquad (6\text{-}1)$$

Where:

TR	=	Target lifetime increased cancer risk (1×10^{-6} or 1E-06)
C_i	=	RME concentration detected in soils (mg/kg)
PRG_i	=	PRG for chemical *i* (mg/kg) based on carcinogenic effects

Similarly, the cumulative RME noncancer HIs will be estimated using the equation below.

$$HI = \sum \left[THI \; x \frac{C_i}{PRG_i} \right] \qquad (6\text{-}2)$$

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Where:

THI	=	target hazard index (assumed 1)
C_i	=	RME concentration detected in soils (mg/kg)
PRG_i	=	PRG for chemical *i* (mg/kg) based on noncarcinogenic effects

It should be noted that HIs are not statistical probabilities, such as CR, and the level of concern does not increase linearly as the reference dose (RfD) is approached or exceeded. For regulatory purposes, an HI of 1 or less is considered an acceptable noncarcinogenic risk level (USEPA 1989, 1990). If the pathway-specific or total exposure HI is greater than 1, the HI will be segregated and evaluated based on the type of effects, or mechanisms of action may have to be considered (USEPA 1989).

To account for potential indoor air exposure to VOCs, indoor air VOC concentrations will be estimated using the San Diego County VOC vapor pathway model as described in Section 5; human intake estimated using Equation 7-4, as presented in Section 7; and cancer risk and noncancer HIs estimated following the methods presented in Sections 8 and 9. Cancer risks and noncancer HIs for indoor air will be added, as applicable, to those calculated using the PRE approach.

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CAS Number	Chemical	Industrial Soils Cancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Industrial Soils Noncancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Residential Soils Cancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Residential Soils Noncancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values
CCR Title 22 Metals (ICP,ICP/MS,GraphiteAA, Hydride) by USEPA 6010B/6020/7000 series or equivalent									
7429-90-5	ALUMINUM			3.54E+05	Cal-EPA			1.40E+04	Cal-EPA
7440-36-0	ANTIMONY			8.79E+02	Cal-EPA			3.36E+01	Cal-EPA
7440-38-2	ARSENIC	2.73E+00	Cal-EPA	4.39E+02	USEPA	3.90E-01	Cal-EPA	2.16E+01	USEPA
7440-39-3	BARIUM			4.11E+04	Cal-EPA			1.63E+03	Cal-EPA
7440-41-7	BERYLLIUM	2.24E+03	Cal-EPA	1.07E+03	Cal-EPA	1.05E+03	Cal-EPA	4.21E+01	Cal-EPA
7440-43-9	CADMIUM	7.12E+03	Cal-EPA	8.10E+02	Cal-EPA	3.34E+03	Cal-EPA	3.70E+01	Cal-EPA
7440-47-3	CHROMIUM	5.44E+03	USEPA			2.56E+03	USEPA		
7440-48-4	COBALT			1.23E+05	Cal-EPA			4.69E+03	Cal-EPA
7440-50-8	COPPER			3.90E+04	USEPA			1.49E+03	USEPA
7439-92-1	LEAD								
7487-94-7	MERCURY			6.13E+02	Cal-EPA			2.35E+01	Cal-EPA
7439-98-7	MOLYBDENUM			1.02E+04	USEPA			3.91E+02	USEPA
7440-02-0	NICKEL			4.09E+04	Cal-EPA			1.56E+03	Cal-EPA
7782-49-2	SELENIUM			5.52E+03	Cal-EPA			2.11E+02	Cal-EPA
7440-22-4	SILVER			1.02E+04	Cal-EPA			3.91E+02	Cal-EPA
7440-28-0	THALLIUM			1.64E+02	Cal-EPA			6.26E+00	Cal-EPA
7440-62-2	VANADIUM			1.43E+04	USEPA			5.48E+02	USEPA
7440-66-6	ZINC			6.13E+05	USEPA			2.35E+04	USEPA
Hexavalent Chromium (Colorimetric) by USEPA 7196A									
18540-29-9	Cr 6+	1.13E+02	Cal-EPA	6.13E+03	USEPA	5.29E+01	Cal-EPA	2.35E+02	USEPA
Polychlorinated Biphenyls (GC/ECD) by USEPA 8082									
12674-11-2	AROCLOR-1016	2.05E+03	Cal-EPA	5.02E+01	Cal-EPA	4.53E+02	Cal-EPA	3.93E+00	Cal-EPA
11104-28-2	AROCLOR-1221	2.51E+00	Cal-EPA	1.44E+01	Cal-EPA	5.55E-01	Cal-EPA	1.12E+00	Cal-EPA
11141-16-5	AROCLOR-1232	2.51E+00	Cal-EPA	1.44E+01	Cal-EPA	5.55E-01	Cal-EPA	1.12E+00	Cal-EPA
53469-21-9	AROCLOR-1242	2.51E+00	Cal-EPA	1.44E+01	Cal-EPA	5.55E-01	Cal-EPA	1.12E+00	Cal-EPA
12672-29-6	AROCLOR-1248	2.51E+00	Cal-EPA	1.44E+01	Cal-EPA	5.55E-01	Cal-EPA	1.12E+00	Cal-EPA
11097-69-1	AROCLOR-1254	2.51E+00	Cal-EPA	1.44E+01	Cal-EPA	5.55E-01	Cal-EPA	1.12E+00	Cal-EPA
11096-82-5	AROCLOR-1260	2.51E+00	Cal-EPA	1.44E+01	Cal-EPA	5.55E-01	Cal-EPA	1.12E+00	Cal-EPA
Polycyclic Aromatic Hydrocarbons (HPLC) by USEPA 8310									
83-32-9	ACENAPHTHENE			3.84E+04	Cal-EPA			3.68E+03	Cal-EPA
208-96-8	ACENAPHTHYLENE			5.42E+04	Cal-EPA			2.31E+03	Cal-EPA
120-12-7	ANTHRACENE			3.90E+05	Cal-EPA			2.19E+04	Cal-EPA
56-55-3	BENZO(A)ANTHRACENE	4.74E+00	Cal-EPA			1.02E+00	Cal-EPA		
50-32-8	BENZO(A)PYRENE	4.74E-01	Cal-EPA			1.02E-01	Cal-EPA		
205-99-2	BENZO(B)FLUORANTHENE	4.74E+00	Cal-EPA			1.02E+00	Cal-EPA		
191-24-2	BENZO(G,H,I)PERYLENE			1.89E+02	Cal-EPA			5.59E+01	Cal-EPA
207-08-9	BENZO(K)FLUORANTHENE	4.74E+02	Cal-EPA			1.02E+02	Cal-EPA		
218-01-9	CHRYSENE	4.74E+03	Cal-EPA			1.02E+03	Cal-EPA		
53-70-3	DIBENZ(A,H)ANTHRACENE	1.62E-01	Cal-EPA			3.49E-02	Cal-EPA		
206-44-0	FLUORANTHENE			3.01E+04	Cal-EPA			2.29E+03	Cal-EPA
86-73-7	FLUORENE			3.31E+04	USEPA			2.64E+03	USEPA
193-39-5	INDENO(1,2,3-CD)PYRENE	4.74E+00	Cal-EPA			1.02E+00	Cal-EPA		
91-20-3	NAPHTHALENE			1.89E+02	Cal-EPA			5.59E+01	Cal-EPA
85-01-8	PHENANTHRENE			5.42E+04	Cal-EPA			2.31E+03	Cal-EPA
129-00-0	PYRENE			5.42E+04	Cal-EPA			2.31E+03	Cal-EPA
Semivolatile Organics (GC/MS) by USEPA 8270C									
120-82-1	1,2,4-TRICHLOROBENZENE			1.93E+03	Cal-EPA			3.56E+02	Cal-EPA
95-50-1	1,2-DICHLOROBENZENE			3.49E+03	Cal-EPA			9.43E+02	Cal-EPA
541-73-1	1,3-DICHLOROBENZENE			5.18E+01	USEPA			1.32E+01	USEPA
106-46-7	1,4-DICHLOROBENZENE	1.19E+01	Cal-EPA	1.25E+04	Cal-EPA	3.27E+00	Cal-EPA	2.75E+03	Cal-EPA

CAS Number	Chemical	Industrial Soils Cancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Industrial Soils Noncancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Residential Soils Cancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Residential Soils Noncancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values
95-95-4	2,4,5-TRICHLOROPHENOL			8.81E+04	USEPA			6.11E+03	USEPA
88-06-2	2,4,6-TRICHLOROPHENOL	1.43E+03	Cal-EPA			2.81E+02	Cal-EPA		
120-83-2	2,4-DICHLOROPHENOL			2.64E+03	USEPA			1.83E+02	USEPA
105-67-9	2,4-DIMETHYLPHENOL			1.76E+04	USEPA			1.22E+03	USEPA
51-28-5	2,4-DINITROPHENOL			1.76E+03	USEPA			1.22E+02	USEPA
121-14-2	2,4-DINITROTOLUENE			1.76E+03	Cal-EPA			1.22E+02	Cal-EPA
606-20-2	2,6-DINITROTOLUENE			8.81E+02	Cal-EPA			6.11E+01	Cal-EPA
91-58-7	2-CHLORONAPHTHALENE			2.73E+04	USEPA			4.94E+03	USEPA
95-57-8	2-CHLOROPHENOL			2.41E+02	USEPA			6.34E+01	USEPA
91-57-6	2-METHYLNAPHTHALENE			1.89E+02	USEPA			5.59E+01	USEPA
95-48-7	2-METHYLPHENOL			4.40E+04	USEPA			3.06E+03	USEPA
88-74-4	2-NITROANILINE			5.03E+01	USEPA			3.49E+00	USEPA
88-75-5	2-NITROPHENOL			7.05E+03				4.89E+02	
91-94-1	3,3'-DICHLOROBENZIDINE	1.46E+01	Cal-EPA			2.88E+00	Cal-EPA		
99-09-2	3-NITROANILINE			5.03E+01	USEPA			3.49E+00	USEPA
534-52-1	4,6-DINITRO-2-METHYLPHENOL			1.76E+03	USEPA			1.22E+02	USEPA
101-55-3	4-BROMOPHENYLPHENYL ETHER								
59-50-7	4-CHLORO-3-METHYLPHENOL			2.41E+02	USEPA			6.34E+01	USEPA
106-47-8	4-CHLOROANILINE			3.52E+03	USEPA			2.44E+02	USEPA
7005-72-3	4-CHLOROPHENYL-PHENYL ETHER								
106-44-5	4-METHYLPHENOL			4.40E+03	USEPA			3.06E+02	USEPA
100-01-6	4-NITROANILINE			5.03E+01	USEPA			3.49E+00	USEPA
100-02-7	4-NITROPHENOL			7.05E+03	USEPA			4.89E+02	USEPA
62-53-3	ANILINE	4.33E+02	Cal-EPA	6.15E+03	USEPA	8.53E+01	Cal-EPA	4.27E+02	USEPA
92-87-5	BENZIDINE	2.33E-02	Cal-EPA	2.64E+03	USEPA	4.60E-03	Cal-EPA	1.83E+02	USEPA
65-85-0	BENZOIC ACID			3.52E+06	USEPA			2.44E+05	USEPA
100-51-6	BENZYL ALCOHOL			2.64E+05	USEPA			1.83E+04	USEPA
111-91-1	BIS(2-CHLOROETHOXY)METHANE								
111-44-4	BIS(2-CHLOROETHYL)ETHER	1.30E+00	USEPA			4.53E-01	USEPA		
108-60-1	BIS(2-CHLOROISOPROPYL)ETHER	7.15E+00	USEPA	4.25E+03	USEPA	2.62E+00	USEPA	9.54E+02	USEPA
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	3.78E+01	Cal-EPA	1.76E+04	Cal-EPA	7.44E+00	Cal-EPA	1.22E+03	Cal-EPA
85-68-7	BUTYLBENZYLPHTHALATE			1.76E+05	Cal-EPA			1.22E+04	Cal-EPA
132-64-9	DIBENZOFURAN			5.06E+03	USEPA			2.91E+02	USEPA
84-66-2	DIETHYLPHTHALATE			7.05E+05	Cal-EPA			4.89E+04	Cal-EPA
131-4-3	DIMETHYPHTHALATE								
84-74-2	DI-N-BUTYLPHTHALATE			8.81E+04	Cal-EPA			6.11E+03	Cal-EPA
117-84-0	DI-N-OCTYLPHTHALATE			1.76E+04	Cal-EPA			1.22E+03	Cal-EPA
118-74-1	HEXACHLOROBENZENE	1.73E+00	Cal-EPA	7.05E+02	Cal-EPA	3.42E-01	Cal-EPA	4.89E+01	Cal-EPA
87-68-3	HEXACHLOROBUTADIENE	3.16E+01	Cal-EPA	1.76E+02	USEPA	6.24E+00	Cal-EPA	1.22E+01	USEPA
77-47-4	HEXACHLOROCYCLOPENTADIENE			6.17E+03	Cal-EPA			4.28E+02	Cal-EPA
67-72-1	HEXACHLOROETHANE	4.91E+02	Cal-EPA	8.81E+02	Cal-EPA	9.68E+01	Cal-EPA	6.11E+01	Cal-EPA
78-59-1	ISOPHORONE	2.60E+03	Cal-EPA	1.76E+05	Cal-EPA	5.12E+02	Cal-EPA	1.22E+04	Cal-EPA
98-95-3	NITROBENZENE			1.20E+02	Cal-EPA			2.01E+01	Cal-EPA
62-75-9	N-NITROSODIMETHYLAMINE	1.52E-02	Cal-EPA			2.99E-03	Cal-EPA		
621-64-7	N-NITROSO-DI-N-PROPYLAMINE	3.52E-01	USEPA			6.95E-02	USEPA		
86-30-6	N-NITROSODIPHENYLAMINE	9.25E+02	Cal-EPA			1.82E+02	Cal-EPA		
87-86-5	PENTACHLOROPHENOL	7.48E+00	Cal-EPA	1.43E+04	USEPA	2.01E+00	Cal-EPA	1.38E+03	USEPA
108-95-2	PHENOL			5.29E+05	USEPA			3.67E+04	USEPA
Total Petroleum Hydrocarbons (GC/FID) by USEPA 8015M Extended Range									
N/A	Total Petroleym Hydrocarbons			8.81E+04	USEPA			6.11E+03	USEPA
Volatile Organics (GC/MS) by USEPA 8260B									
630-20-6	1,1,1,2-TETRACHLOROETHANE	7.04E+00	USEPA	1.95E+03	USEPA	3.00E+00	USEPA	4.89E+02	USEPA
71-55-6	1,1,1-TRICHLOROETHANE			3.48E+03	Cal-EPA			1.05E+03	Cal-EPA
79-34-5	1,1,2,2-TETRACHLOROETHANE	9.06E-01	Cal-EPA	2.67E+02	Cal-EPA	3.96E-01	Cal-EPA	1.09E+01	Cal-EPA

Industrial and Residential Preliminary Remediation Goals

CAS Number	Chemical	Industrial Soils Cancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Industrial Soils Noncancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Residential Soils Cancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Residential Soils Noncancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values
79-00-5	1,1,2-TRICHLOROETHANE	1.04E+02	Cal-EPA	1.52E+02	Cal-EPA	1.35E+01	Cal-EPA	4.12E+01	Cal-EPA
75-34-3	1,1-DICHLOROETHANE			1.48E+03	Cal-EPA			4.30E+02	Cal-EPA
75-35-4	1,1-DICHLOROETHENE	1.15E-01	Cal-EPA	6.74E+01	Cal-EPA	5.22E-02	Cal-EPA	2.01E+01	Cal-EPA
563-58-6	1,1-DICHLOROPROPENE	7.53E-02	Cal-EPA	4.62E+01	Cal-EPA	3.49E-02	Cal-EPA	9.26E+00	Cal-EPA
87-61-6	1,2,3-TRICHLOROBENZENE			1.93E+03	USEPA			3.56E+02	USEPA
96-18-4	1,2,3-TRICHLOROPROPANE	3.09E-03	USEPA	3.86E+01	USEPA	1.43E-03	USEPA	1.16E+01	USEPA
120-82-1	1,2,4-TRICHLOROBENZENE			1.93E+03	Cal-EPA			3.56E+02	Cal-EPA
95-63-6	1,2,4-TRIMETHYLBENZENE			1.71E+02	USEPA			5.16E+01	USEPA
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	2.04E+01	Cal-EPA	6.92E+00	USEPA	2.29E+00	Cal-EPA	1.50E+00	USEPA
106-93-4	1,2-DIBROMOETHANE	2.71E-03	Cal-EPA	2.62E+00	USEPA	3.15E-04	Cal-EPA	6.94E-01	USEPA
95-50-1	1,2-DICHLOROBENZENE			3.49E+03	Cal-EPA			9.43E+02	Cal-EPA
107-06-2	1,2-DICHLOROETHANE	5.85E-01	Cal-EPA	3.52E+01	USEPA	2.60E-01	Cal-EPA	1.07E+01	USEPA
78-87-5	1,2-DICHLOROPROPANE	4.06E-01	Cal-EPA	1.94E+01	Cal-EPA	1.86E-01	Cal-EPA	5.60E+00	Cal-EPA
108-67-8	1,3,5-TRIMETHYLBENZENE			6.98E+01	Cal-EPA			2.13E+01	Cal-EPA
541-73-1	1,3-DICHLOROBENZENE			5.18E+01	Cal-EPA			1.32E+01	Cal-EPA
106-46-7	1,4-DICHLOROBENZENE	1.19E+01	Cal-EPA	1.25E+04	USEPA	3.27E+00	Cal-EPA	2.75E+03	USEPA
123-91-1	1,4-DIOXANE	5.50E+02	Cal-EPA			1.09E+02	Cal-EPA		
594-20-7	2,2-DICHLOROPROPANE								
78-93-3	2-BUTANONE (MEK)			4.16E+04	Cal-EPA			1.03E+04	Cal-EPA
110-75-8	2-CHLOROETHYLVINYL ETHER								
95-49-8	2-CHLOROTOLUENE			5.68E+02				1.58E+02	
591-78-6	2-HEXANONE			2.89E+03				7.87E+02	
106-43-4	4-CHLOROTOLUENE			5.68E+02				1.58E+02	
108-10-1	4-METHYL-2-PENTANONE (MIBK)			2.89E+03				7.87E+02	
67-64-1	ACETONE			6.22E+03	Cal-EPA			1.57E+03	Cal-EPA
75-05-8	ACETONITRILE			1.74E+03				2.67E+02	
107-02-8	ACROLEIN			3.37E-01				1.03E-01	
107-13-1	ACRYLONITRILE	2.02E+00	Cal-EPA	2.59E+01		7.14E-01	Cal-EPA	7.29E+00	
71-43-2	BENZENE	5.42E+00	Cal-EPA	2.34E+02	Cal-EPA	2.48E+00	Cal-EPA	5.65E+01	Cal-EPA
108-86-1	BROMOBENZENE			9.24E+01				2.83E+01	
74-97-5	BROMOCHLOROMETHANE	4.94E+00	Cal-EPA	1.04E+03	Cal-EPA	2.15E+00	Cal-EPA	2.71E+02	Cal-EPA
75-27-4	BROMODICHLOROMETHANE	4.94E+00	Cal-EPA	1.04E+03	Cal-EPA	2.15E+00	Cal-EPA	2.71E+02	Cal-EPA
75-25-2	BROMOFORM	3.12E+02	Cal-EPA	1.76E+04	Cal-EPA	6.16E+01	Cal-EPA	1.22E+03	Cal-EPA
74-83-9	BROMOMETHANE			9.40E+00	Cal-EPA			2.81E+00	Cal-EPA
75-15-0	CARBON DISULFIDE			1.82E+01	Cal-EPA			5.58E+00	Cal-EPA
56-23-5	CARBON TETRACHLORIDE	1.47E+00	Cal-EPA	7.00E+00	Cal-EPA	6.33E-01	Cal-EPA	2.07E+00	Cal-EPA
108-90-7	CHLOROBENZENE			1.93E+02	Cal-EPA			5.73E+01	Cal-EPA
75-00-3	CHLOROETHANE	6.51E+00	USEPA	1.89E+04	USEPA	3.03E+00	USEPA	4.97E+03	USEPA
67-66-3	CHLOROFORM	1.22E-01	Cal-EPA	1.49E+02	Cal-EPA	5.75E-02	Cal-EPA	4.33E+01	Cal-EPA
74-87-3	CHLOROMETHANE	2.66E+00	USEPA			1.23E+00	USEPA		
156-59-2	CIS-1,2-DICHLOROETHENE			1.37E+02	Cal-EPA			2.70E+01	Cal-EPA
10061-01-5	CIS-1,3-DICHLOROPROPENE	7.53E-02	Cal-EPA	4.62E+01	Cal-EPA	3.49E-02	Cal-EPA	9.26E+00	Cal-EPA
124-48-1	DIBROMOCHLOROMETHANE	2.97E+00	Cal-EPA	1.59E+03	Cal-EPA	1.24E+00	Cal-EPA	3.83E+02	Cal-EPA
75-71-8	DICHLORODIFLUOROMETHANE (Freon 12)			3.08E+02	Cal-EPA			9.37E+01	Cal-EPA
100-41-4	ETHYLBENZENE			7.60E+04	Cal-EPA			6.46E+03	Cal-EPA
87-68-3	HEXACHLOROBUTADIENE	3.16E+01	Cal-EPA	1.76E+02	USEPA	6.24E+00	Cal-EPA	1.22E+01	USEPA
74-88-4	IODOMETHANE								
98-82-8	ISOPROPYLBENZENE			5.22E+02	USEPA			1.57E+02	USEPA
108-20-3	ISOPROPYL ETHER (DIPE)								
75-09-2	METHYLENE CHLORIDE	4.47E+01	Cal-EPA	1.73E+02	Cal-EPA	1.91E+01	Cal-EPA	5.23E+01	Cal-EPA
1634-04-4	METHYL-T-BUTYL ETHER (MTBE)								
104-51-8	N-BUTYLBENZENE			5.64E+02	USEPA			1.45E+02	USEPA
103-65-1	N-PROPYLBENZENE			5.64E+02	USEPA			1.45E+02	USEPA
99-87-6	P-ISOPROPYL TOLUENE			4.35E+04	Cal-EPA			1.23E+04	Cal-EPA
135-9-88	SEC-BUTYLBENZENE			4.16E+02	USEPA			1.11E+02	USEPA
100-42-5	STYRENE			2.11E+04	Cal-EPA			4.75E+03	Cal-EPA

CAS Number	Chemical	Industrial Soils Cancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Industrial Soils Noncancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Residential Soils Cancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values	Residential Soils Noncancer Endpoint (Integrated) (mg/kg)	Source of Toxicity Values
75-65-0	T-BUTANOL			7.66E+04	USEPA			1.25E+04	USEPA
98-06-6	T-BUTYLBENZENE			5.03E+02	USEPA			1.31E+02	USEPA
994-05-8	TERT-AMYL METHYL ETHER (TAME)								
637-92-3	TERT-BUTYL ETHYL ETHER (ETBE)								
127-18-4	TETRACHLOROETHENE (PCE)	7.41E+01	Cal-EPA	1.68E+02	Cal-EPA	1.09E+01	Cal-EPA	4.85E+01	Cal-EPA
109-99-9	TETRAHYDROFURAN	3.25E+02	USEPA	1.85E+05	USEPA	6.40E+01	USEPA	1.28E+04	USEPA
108-88-3	TOLUENE			5.44E+02	Cal-EPA			1.65E+02	Cal-EPA
156-60-5	TRANS-1,2-DICHLOROETHENE			2.14E+02	Cal-EPA			6.32E+01	Cal-EPA
10061-02-6	TRANS-1,3-DICHLOROPROPENE	7.53E-02	Cal-EPA	4.62E+01	Cal-EPA	3.49E-02	Cal-EPA	9.26E+00	Cal-EPA
79-01-6	TRICHLOROETHENE (TCE)	1.02E+01	Cal-EPA	7.91E+01	USEPA	4.57E+00	Cal-EPA	2.32E+01	USEPA
75-69-4	TRICHLOROFLUOROMETHANE			1.28E+03	Cal-EPA			3.82E+02	Cal-EPA
108-05-4	VINYL ACETATE			1.40E+03	USEPA			4.26E+02	USEPA
75-01-4	VINYL CHLORIDE	4.03E-02	Cal-EPA			1.46E-02	Cal-EPA		
1330-20-7	XYLENES (TOTAL)			4.35E+04	Cal-EPA			1.23E+04	Cal-EPA
Perchlorate (Ion Chromatography) by USEPA 314.0									
14797-73-0	PERCHLORATE			1.00E+03				3.90E+01	
Total Cyanide (Distillation) by USEPA 9010B / 9014									
57-12-5	CYANIDE (TOTAL)			3.50E+04					
Amenable Cyanide (Distillation) by USEPA 9012									
57-12-5	CYANIDE (AMENABLE)			3.50E+04				2.40E+03	

Key:
PRG= Preliminary Remediation Goals
CAS= Chemical Abstracts Service
USEPA= U.S. Environmental Protection Agency
Cal-EPA= California Environmental Protection Agency
mg/kg= milligrams per kilogram

SECTION 7
HUMAN EXPOSURE MODELS

Human exposure models provide the basis for quantifying potential exposure to COPCs. The exposure models are based on the calculation of human intake for each COPC. For noncarcinogenic effects, intake is averaged over the period of exposure and is referred to as the average daily intake (ADI). For carcinogenic effects, the intake is averaged over a lifetime and is referred to as the lifetime average daily intake (LADI).

Consistent with current DTSC (1992) and USEPA guidance (1989), the following general equation will be applied to assess chemical intake for each complete or potentially complete exposure pathway considered in each risk assessment:

$$Intake = \frac{C \times IR \times EF \times ED \times RAF}{BW \times AT} \qquad (7\text{-}1)$$

where:

Intake	=	ADI (mg/kg-day) for noncarcinogens LADI (mg/kg-day) for carcinogens
C	=	COPC EPC in environmental medium (mg/kg soil; milligrams per liter [mg/L] water; or, mg/m^3 air)
IR	=	intake rate (mg soil/day; or, m^3 air/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
RAF	=	relative absorption factor (fraction) (i.e., the ratio of bioavailability in the exposure scenario to bioavailability in the exposure situation from which the toxicity criteria is based)
BW	=	body weight (kg)
AT	=	averaging time (days)

With the exception of EPCs (discussed in Section 5), explanation of the specific parameters applied to this general equation and recommended parameter values are presented in this section.

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Estimation of exposure may proceed in a deterministic or probabilistic fashion. A deterministic analysis will be presented along with any probabilistic analysis. The deterministic approach provides a "point estimate" of exposure by specifying constant values for each equation parameter. Probabilistic estimation considers a range of values that might be applied to each exposure factor. Variables for each parameter are selected at random from a probability distribution (i.e., each factor is a random variable) and the risk estimate is calculated multiple times, resulting in a probability distribution of risk (a cumulative frequency distribution) that is a continuum of possible risk estimates accounting for the variability of each exposure parameter.

The cumulative frequency is a measure of the confidence of the estimate. That is, it shows the probability of any given risk estimate. To the extent that the random exposure values represent variation in a population, the cumulative frequency plot indicates the proportion of a specified population that might be associated with the estimated exposure (and corresponding health risk)[1].

The probabilistic approach is a comprehensive treatment of the risk estimate, which may be helpful to risk managers who are charged with balancing risk reduction against cost and/or technical feasibility of a response, and the potential to create a competing risk during remediation activities. However, the probabilistic method is complicated to implement. A certain amount of information about the variability in an exposure estimate may be obtained simply by using the deterministic system to calculate exposure for different point estimates (e.g., RME). The point estimates may represent the typical or central tendency exposure (CTE) among the plausible range of exposures or an estimate of the RME.

Either deterministic or combined deterministic and probabilistic approaches may be used for the exposure areas, depending on an assessment of the practicality and need for probabilistic risk assessment. At a minimum, all exposure areas will be evaluated to provide CTE and RME (deterministic) intake estimates. Based on the results of the deterministic intake estimates, probabilistic-based intake estimates may be calculated for specific pathways.

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[1] It is important to note that for most distributions used to specify the random variables, it is not possible to separate that variation produced by measurement error from actual variability in human behavior or physiological traits producing the exposure. As such, the cumulative frequency distribution is only a crude indication of the potential distribution of risk within a population.

The pathway-specific intake equations for each scenario are presented below, along with recommended deterministic parameter values and parameter value distributions for probabilistic assessment for several parameters (see Tables 7-1 through 7-6). In some cases, it was determined that a distribution would not be applied to a parameter either because varying the parameter would not produce significantly different estimates of exposure, or because no information on the distribution was available. Sources for exposure parameter values are specified, but came primarily from default exposure parameters noted in Cal-EPA's risk assessment modeling tool CalTOX (DTSC 1993), the DTSC *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Facilities and Permitted Facilities* (DTSC 1992), or the USEPA *Exposure Factors Handbook* (USEPA 1997).

CalTOX is compatible with probabilistic exposure estimations and provides default distributions for many exposure parameters (DTSC 1993). It was used as the priority source for the distributions recommended herein. Alternative distributions from other sources were used only where newer or more specific distributions were available, or where no distribution was offered in DTSC (1993).

Human receptors may be exposed to COPCs in soil through direct contact with soil (e.g., incidental ingestion, dermal contact), by inhalation of soil particulates, or as a result of vapor migration from subsurface depths into buildings (inhalation of indoor air). Intake equations for these pathways are presented below.

7.1 INCIDENTAL INGESTION OF SOIL

Chemical uptake via ingestion of soil will be calculated according to the following equation (USEPA 1989):

$$Intake = \frac{C_{soil} \times IR_{soil} \times CF \times EF \times ED \times RAF}{BW \times AT} \qquad (7\text{-}2)$$

where:

$Intake$ = intake for each chemical of concern (mg/kg-day)
C_{soil} = COPC EPC in soil (mg/kg)

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IR_{soil} = soil ingestion rate (mg/day)
CF = conversion factor (10^{-6} kg/mg)
EF = exposure frequency (days/year)
ED = exposure duration (years)
RAF = relative absorption factor (fraction)
BW = body weight (kg)
AT = averaging time (period over which exposure is averaged - days)
(= ED for noncarcinogens; 75 years for carcinogens)

Chemical-specific oral bioavailability factors will be applied when the oral toxicity criteria are based on administered dose, or when oral studies are available in the peer-reviewed literature that report gastrointestinal absorption fractions for chemicals administered in a soil matrix.

Exposure parameter values for soil ingestion are provided in Tables 7-1 and 7-4 for the onsite construction worker during property redevelopment excavation and grading activities, and the onsite gardener/landscaper after property redevelopment, respectively. It should be noted from these tables, that the only exposure parameters not taken from the priority sources previously specified (see page 7-3) are exposure frequency distribution values.

7.2 Dermal Contact with Soil

Chemical intake via dermal contact with surficial soil will be calculated according to the following equation (USEPA 1989):

$$Intake = \frac{C_{soil} \times LR \times CR \times RAF \times CF \times EF \times ED}{BW \times AT} \quad (7\text{-}3)$$

where:

$Intake$ = intake for each chemical of concern (mg/kg-day)
C_{soil} = COPC EPC in soil (mg chemical/kg soil)
LR = soil loading to skin (mg soil/day), where $LR = AF \times SA$, where AF = soil adherence factor (mg/cm^2-event) and SA = skin surface area (cm^2)
CR = contact rate, events/day

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RAF = relative absorption factor (fraction)
CF = conversion factor (10^{-6} kg/mg)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (period over which exposure is averaged - days)
(= ED for noncarcinogens; 75 years for carcinogens)

Chemical-specific dermal bioavailability factors will be taken from Cal-EPA guidance (DTSC 1994).

Exposure parameter values for dermal contact are provided in Tables 7-1 and 7-4 for the onsite construction worker during property redevelopment excavation and grading activities, and gardener/landscaper after property redevelopment, respectively. Distributions of these parameters for use in probabilistic risk assessment were obtained from DTSC (1999) and the draft USEPA (1999) dermal risk assessment guidance or developed from pooled data (geometric means and standard deviations) for relevant experimental groups provided in the pending dermal guidance or USEPA (1997) using the software *Crystal Ball* (Decisioneering, Inc., Denver, Colorado).

7.3 INHALATION OF VAPORS

Chemical intake via inhalation of vapors released to indoor air will be calculated according to the following equation (USEPA 1989):

$$Intake = \frac{C_{air} \times IR_{air} \times EF \times ED}{BW \times AT} \qquad (7\text{-}4)$$

where:

$Intake$ = intake for each chemical of concern (mg/kg-day)
C_{air} = COPC vapor concentration in air (mg/m^3)
IR_{air} = inhalation rate (m^3/day), where IR_{air} = BR x EF_f, where BR = breathing rate (m^3/hr) and EF_f= fraction of day exposed (hr/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)

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BW = body weight (kg)

AT = averaging time (period over which exposure is averaged - days)
(= ED for noncarcinogens; 75 years for carcinogens)

The air concentration for this algorithm may be computed from the vapor pathway model described in Section 5. Exposure parameter values for indoor air vapor inhalation are provided in Tables 7-3, 7-5, 7-6, and 7-7 for the onsite light industrial/commercial worker and offsite residential child and residential adult or offsite light industrial/commercial worker after property redevelopment, respectively. It should be noted from these tables that the only exposure parameters not taken from the priority sources previously specified (see page 7-5) is the body weight distribution for children.

Body weights for children were adjusted because CalTOX evaluates a "child" between the ages of 0 to 15 years, whereas this document specifies the more typical child age range of 1 to 6 years. As such, the CalTOX-specified body weight would be too high for the younger receptor, causing an underestimate of exposure. No published distributions of body weight were available for this age range, but Anderson et al. (1985, same data cited in USEPA 1997) provide percentiles of body weights on a year-by-year basis for children. A 3- to 4-year-old child was used, as this is the mid-point age for the receptor in question and notes in USEPA (1997) that the reported percentiles fit a normal distribution where the mean (50th percentile) equals 15.6 kilograms (kg), and the standard deviation equals approximately 2 kg.

Residential adult inhalation rates for deterministic risk evaluation were obtained from USEPA (1997) and were set at recommended resting rates for the residential exposure. Children's inhalation rates for deterministic evaluation were obtained from USEPA (1997) and relate to the mean inhalation rate recommended for a child from age 3 to 5 years. The distribution provided by CalTOX for children relates to ages 0 to 15 years and would not be appropriate for the 1- to 6-year-old receptor considered here. Therefore, the distribution assigned is the adult distribution multiplied by 0.75, which is the approximate ratio of child to adult breathing rates selected for the deterministic evaluation.

This equation may also be used to quantify exposure to vapors migrating from groundwater into a structure. As indicated in Section 5, because the migration pathway from groundwater would be through the vadose zone soil column, it is possible that combined modeling of both vapor transport from groundwater and from soil could

amount to "double counting" the resulting ambient indoor air concentration. Whereas, modeling of indoor air concentrations using soil gas data provides estimated indoor air concentrations from combined soil and groundwater sources. Therefore, when soil and groundwater data (as opposed to soil gas data) are used to derive indoor air concentrations, the greatest of the calculated indoor air EPCs using either the soil or the groundwater data set will be used in the risk assessment.

7.4 INHALATION OF PARTICULATES

Chemical intake via inhalation of particulates (for semivolatile and nonvolatile compounds) will be calculated according to the following equation (USEPA 1989):

$$Intake = \frac{C_{soil} \times IR_{air} \times EF \times ED}{PEF \times BW \times AT} \qquad (7\text{-}5)$$

where:

$Intake$	=	intake for each chemical of concern (mg/kg-day)
C_{soil}	=	COPC EPC in soil (mg/kg)
PEF	=	particulate emission factor (m^3/kg)
IR_{air}	=	inhalation rate (m^3/day), where $IR_{air} = BR \times EF_f$, where BR = breathing rate (m^3/hr) and EF_f = fraction of day exposed (hr/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT	=	averaging time (period over which exposure is averaged - days) (= ED for noncarcinogens; 75 years for carcinogens)

Exposure parameter values for particulate inhalation are provided in Tables 7-1, 7-2, and 7-7 for the onsite construction worker and offsite residential child or offsite light industrial/commercial worker during property redevelopment excavation and grading activities, and in Table 7-4 for the onsite gardener/landscaper after property redevelopment, respectively. Inhalation rates (both deterministic values and distribution) for the construction worker and the gardener/landscaper were obtained from USEPA (1999a) and represent data for outdoor workers.

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Table 7-1 (Page 1 of 3)

EXPOSURE ASSESSMENT PARAMETERS FOR AN ONSITE CONSTRUCTION WORKER – DURING PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
General Parameters:			
Body Weight (BW)	Value: 70 kg Rationale: Average body weight, USEPA 1997	Lognormal mean: 71 kg standard deviation: 14.2 Source: CalTOX 1994[1]	Value: 70 kg Rationale: Average body weight, USEPA 1997
Exposure Frequency (EF)	Value: 8 hrs/d, 219 d/yr Rationale: DTSC 1999	Constant	Value: 8 hrs/d, 250 d/yr Rationale: USEPA 1997
Exposure Duration (ED)	Value: 6 months Rationale: Estimated average time required for construction	Continuous variable across age-specific occupational tenure reported by Carey (1988) as presented by USEPA (1997)	Value: 1 year Rationale: Estimated maximum time for construction
Averaging Time (AT)	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: USEPA 1997	Carcinogenic Effects: Constant at 75 years Noncarcinogenic Effects: Co-vary with exposure duration	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: USEPA 1997
Inhalation of Particulates:			
Breathing Rate (BR)	Value: 1.3 m^3/hr Rationale: Hourly average for outdoor workers, USEPA 1997	Lognormal mean: 1.44 m^3/hr standard deviation: 0.66 m^3/hr Rationale: General construction workers and laborers reported by Linn et al. (1993) as presented by USEPA (1997)	Value: 2.0 m^3/hour Rationale: Midpoint between moderate and heavy activity values, USEPA 1997

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Table 7-1 (Page 2 of 3)

EXPOSURE ASSESSMENT PARAMETERS FOR AN ONSITE CONSTRUCTION WORKER – DURING PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
Dermal Contact with Soil:			
Soil Adherence Factor (AF)	Value: 0.1 mg/cm^3 Rationale: Weighted soil adherence for face, forearms, and hands for pooled construction worker data (USEPA 1999); typical activity combined with 50th percentile body part-specific soil adherence factors	Empirical Distribution Rationale: Distribution from anticipated USEPA Dermal Guidance or fitted distribution of pooled data from sources cited in that Guidance	Value: 0.3 mg/m^3 Rationale: Weighted soil adherence for face, forearms, and hands for pooled construction worker data (USEPA 1999); high-end activity combined with 95th percentile body part-specific soil adherence factors
Contact Rate (CR)	Value: 2/day Rationale: Professional judgment	Continuous variable between CTE and RME values Rationale: Professional judgment	Value: 4/day Rationale: Professional judgment
Surface Area (SA)	Value: 2,500 cm^2 Rationale: DTSC 1999	Empirical Distribution Co-vary with body weight Rationale: Distribution developed from percentile values (USEPA 1997, Tables 6-2, 6-3), summed across relevent body parts, and fitted to Crystal Ball	Value: 2,500 cm^2 Rationale: DTSC 1999
Relative Absorption Factor (RAF)	Value: Chemical-specific: 0.1 for VOCs; 0.001 for Cd; 0.03 for As; 0.01 for other metals Rationale: DTSC 1994; for other COPCs - current peer-reviewed literature values for chemical in soil matrix	Constant	Value: Chemical-specific: 0.1 for VOCs; 0.001 for Cd; 0.03 for As; 0.01 for other metals Rationale: DTSC 1994; for other COPCs, current peer-reviewed literature values for chemical in soil matrix

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Table 7-1 (Page 3 of 3)

EXPOSURE ASSESSMENT PARAMETERS FOR AN ONSITE CONSTRUCTION WORKER – DURING PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
Incidental Soil Ingestion:			
Ingestion Rate (IR_{soil})	Value: 50 mg/day Rationale: Based on range of plausible soil ingestion rates for adults, USEPA 1997	Lognormal mean: 9.94 mg/day standard deviation: 19.9 mg/day Source: CalTOX 1994[1]	Value: 200 mg/day Rationale: RME ingestion rate, DTSC, personal communication, T.R. Hathaway, 3/30/00
Relative Absorption Factor (RAF)	Value: Chemical-specific Rationale: Current peer-reviewed literature values for chemical in soil matrix	Constant	Value: Chemical-specific Rationale: Current peer-reviewed literature values for chemical in soil matrix

[1] CalTOX computer model version 1994.
Crystal Ball (Decisioneering, Inc., Denver, CO)

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Table 7-2 (Page 1 of 2)

EXPOSURE ASSESSMENT PARAMETERS FOR AN OFFSITE RESIDENTIAL CHILD – DURING PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
General Parameters:			
Body Weight (BW)	Value: 15 kg Rationale: Average body weight (at midpoint of 1- to 6-year-olds), USEPA 1997; DTSC 1992	Normal mean: 15.6 kg standard deviation: 2 kg Rationale: Fit of reported percentiles of body weight for 3- to 4-year-olds (mid-point of 1- to 6-year-old receptor) as reported in Anderson et al. 1985	Value: 15 kg Rationale: Average body weight (at midpoint of 1- to 6-year-olds); USEPA 1997; DTSC 1992
Exposure Frequency (EF)	Value: 350 days/year Rationale: USEPA 1997; DTSC 1992	Constant	Value: 350 days/year Rationale: USEPA 1997; DTSC 1992
Exposure Duration (ED)	Value: 6 months Rationale: Estimated average time required for construction	Continuous variable between CTE value of 6 months and RME value of 1 year Rationale: Professional judgment	Value: 1 year Rationale: Estimated maximum time for construction
Averaging Time (AT)	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: Average lifetime, USEPA 1997; Exposure duration, DTSC 1992	Carcinogenic Effects: Constant at 75 years Noncarcinogenic Effects: Co-vary with exposure duration	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: Average lifetime, USEPA 1997; Exposure duration, DTSC 1992

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Table 7-2 (Page 2 of 2)

EXPOSURE ASSESSMENT PARAMETERS FOR AN OFFSITE RESIDENTIAL CHILD – DURING PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
Inhalation of Particulates:			
Breathing Rate (BR)	Value: 1.1 m^3/hour Rationale: Midpoint between recommended values for RME for light and moderate activity in children; USEPA 1997	Lognormal mean: 1.08 m^3/hour standard deviation: 0.32 m^3/hour Source: Active inhalation rate in adults times 0.86 (ratio of child to adult recommended rates in USEPA 1997); CalTOX 1994[1]	Value: 1.1 m^3/hour Rationale: Midpoint between recommended values for RME for light and moderate activity in children, USEPA 1997

[1] CalTOX computer model version 1994.
Crystal Ball (Decisioneering, Inc., Denver, CO)

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Table 7-3 (Page 1 of 1)

EXPOSURE ASSESSMENT PARAMETERS FOR AN ONSITE LIGHT INDUSTRIAL/COMMERCIAL WORKER – AFTER PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
General Parameters:			
Body Weight (BW)	Value: 70 kg Rationale: Average body weight, USEPA 1997	Lognormal mean: 71 kg standard deviation: 14.2 Source: CalTOX 1994[1]	Value: 70 kg Rationale: Average body weight, USEPA 1997
Exposure Frequency (EF)	Value: 8 hrs/d, 219 d/yr Rationale: DTSC 1999	Constant	Value: 8 hrs/d, 250 d/yr Rationale: USEPA 1997
Exposure Duration (ED)	Value: 9 years Rationale: DTSC 1999	Continuous variable across age-specific occupational tenure reported by Carey (1988) as presented by USEPA (1997)	Value: 25 years Rationale: DTSC 1999
Averaging Time (AT)	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: USEPA 1997	Carcinogenic Effects: Constant at 75 years Noncarcinogenic Effects: Co-vary with exposure duration	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: USEPA 1997
Inhalation of Indoor Vapors:			
Breathing Rate (BR)	Value: 1.3 m^3/hr Rationale: Hourly average for outdoor workers, USEPA 1997	Lognormal mean: 1.44 m^3/hr standard deviation: 0.66 m^3/hr Rationale: General construction workers and laborers reported by Linn et al. (1993) as presented by USEPA (1997)	Value: 2.0 m^3/hour Rationale: Midpoint between moderate and heavy activity values, USEPA 1997

[1] CalTOX computer model version 1994.
Crystal Ball (Decisioneering, Inc., Denver, CO

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Table 7-4 (Page 1 of 3)

EXPOSURE ASSESSMENT PARAMETERS FOR AN ONSITE GARDENER/LANDSCAPER – AFTER PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
General Parameters:			
Body Weight (BW)	Value: 70 kg Rationale: Average body weight, USEPA 1997	Lognormal mean: 71 kg standard deviation: 14.2 Source: CalTOX 1994[1]	Value: 70 kg Rationale: Average body weight, USEPA 1997
Exposure Frequency (EF)	Value: 8 hrs/d, 219 d/yr Rationale: DTSC 1999	Constant	Value: 8 hrs/d, 250 d/yr Rationale: USEPA 1997
Exposure Duration (ED)	Value: 9 years Rationale: DTSC 1999	Continuous variable across age-specific occupational tenure reported by Carey (1988) as presented by USEPA (1997)	Value: 25 years Rationale: DTSC 1999
Averaging Time (AT)	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: USEPA 1997	Carcinogenic Effects: Constant at 75 years Noncarcinogenic Effects: Co-vary with exposure duration	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: USEPA 1997
Inhalation of Particulates:			
Breathing Rate (BR)	Value: 1.3 m^3/hr Rationale: Hourly average for outdoor workers, USEPA 1997	Lognormal mean: 1.44 m^3/hr standard deviation: 0.66 m^3/hr Rationale: General construction workers and laborers reported by Linn et al. (1993) as presented by USEPA (1997)	Value: 2.0 m^3/hour Rationale: Midpoint between moderate and heavy activity values, USEPA 1997

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Table 7-4 (Page 2 of 3)

EXPOSURE ASSESSMENT PARAMETERS FOR AN ONSITE GARDENER/LANDSCAPER – AFTER PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
Dermal Contact with Soil:			
Soil Adherence Factor (AF)	Value: 0.1 mg/cm^2 Rationale: Weighted soil adherence for face, forearms, and hands for pooled gardener data (USEPA 1999); typical activity combined with 50th percentile body part-specific soil adherence factors	Empirical Distribution Rationale: Distribution from anticipated USEPA Dermal Guidance	Value: 0.4 mg/cm^2 Rationale: Weighted soil adherence for face, forearms, and hands for pooled gardener data (USEPA 1999); high-end activity combined with 95th percentile body part-specific soil adherence factors
Contact Rate (CR)	Value: 2/day Rationale: Professional judgment	Continuous variable between CTE and RME values. Rationale: Professional judgment	Value: 4/day Rationale: Professional judgment
Surface Area (SA)	Value: 3,300 cm^2 Rationale: USEPA 1999	Empirical Distribution Co-vary with body weight Rationale: Distribution developed from percentile values (USEPA 1997, Tables 6-2, 6-3), summed across relevent body parts, and fitted to Crystal Ball	Value: 3,300 cm^2 Rationale: USEPA 1999
Relative Absorption Factor (RAF)	Value: Chemical-specific: 0.1 for VOCs; 0.001 for Cd; 0.03 for As; 0.01 for other metals Rationale: DTSC 1994; for other COPCs - current peer-reviewed literature values for chemical in soil matrix	Constant	Value: Chemical-specific: 0.1 for VOCs; 0.001 for Cd; 0.03 for As; 0.01 for other metals Rationale: DTSC 1994; for other COPCs - current peer-reviewed literature values for chemical in soil matrix

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Table 7-4 (Page 3 of 3)

EXPOSURE ASSESSMENT PARAMETERS FOR AN ONSITE GARDENER/LANDSCAPER – AFTER PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
Incidental Soil Ingestion:			
Ingestion Rate (IR_{soil})	Value: 50 mg/day Rationale: Based on range of plausible soil ingestion rates for adults, USEPA 1997	Lognormal mean: 9.94 mg/day standard deviation: 19.9 mg/day Source: CalTOX 1994[1]	Value: 200 mg/day Rationale: RME ingestion rate, DTSC, personal communication, T.R. Hathaway, 3/30/00
Relative Absorption Factor (RAF)	Value: Chemical-specific Rationale: Current peer-reviewed literature values for chemical in soil matrix	Constant	Value: Chemical-specific Rationale: Current peer-reviewed literature values for chemical in soil matrix

[1] CalTOX computer model version 1994.
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Table 7-5 (Page 1 of 2)

EXPOSURE ASSESSMENT PARAMETERS FOR AN OFFSITE RESIDENTIAL CHILD – AFTER PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
General Parameters:			
Body Weight (BW)	Value: 15 kg Rationale: Average body weight (at midpoint of 1- to 6-year-olds), USEPA 1997; DTSC 1992	Normal mean: 15.6 kg standard deviation: 2 kg Rationale: Fit of reported percentiles of body weight for 3- to 4-year-olds (mid-point of 1- to 6-year-old receptor) as reported in Anderson et al. 1985	Value: 15 kg Rationale: Average body weight (at midpoint of 1- to 6-year-olds); USEPA 1997; DTSC 1992
Exposure Frequency (EF)	Value: 350 days/year Rationale: USEPA 1997; DTSC 1992	Constant	Value: 350 days/year Rationale: USEPA 1997; DTSC 1992
Exposure Duration (ED)	Value: 6 months Rationale: Estimated average time required for construction	Continuous variable between CTE value of 6 months and RME value of 1 year Rationale: Professional judgment	Value: 1 year Rationale: Estimated maximum time for construction
Averaging Time (AT)	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: Average lifetime, USEPA 1997; Exposure duration, DTSC 1992	Carcinogenic Effects: Constant at 75 years Noncarcinogenic Effects: Co-vary with exposure duration	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: Average lifetime, USEPA 1997; Exposure duration, DTSC 1992

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EXPOSURE ASSESSMENT PARAMETERS FOR AN OFFSITE RESIDENTIAL CHILD – AFTER PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
Inhalation of Particulates:			
Breathing Rate (BR)	Value: 1.1 m^3/hour Rationale: Midpoint between recommended values for RME for light and moderate activity in children; USEPA 1997	Lognormal mean: 1.08 m^3/hour standard deviation: 0.32 m^3/hour Source: Active inhalation rate in adults times 0.86 (ratio of child to adult recommended rates in USEPA 1997); CalTOX 1994[1]	Value: 1.1 m^3/hour Rationale: Midpoint between recommended values for RME for light and moderate activity in children, USEPA 1997
Hours of day spent in or near home (Ef_f)	Value: 24 h/d Rationale: Small preschool child not anticipated to spend large amounts of time away from home	Constant	24 h/d Rationale: Small preschool child not anticipated to spend large amounts of time away from home

[1] CalTOX computer model version 1994.
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Table 7-6 (Page 1 of 2)

EXPOSURE ASSESSMENT PARAMETERS FOR AN OFFSITE RESIDENTIAL ADULT – AFTER PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
General Parameters:			
Body Weight (BW)	Value: 70 kg Rationale: Average body weight, USEPA 1997	Lognormal mean: 71 kg standard deviation: 14.2 Source: CalTOX 1994[1]	Value: 70 kg Rationale: Average body weight, USEPA 1997
Exposure Frequency (EF)	Value: 350 days/year Rationale: USEPA 1997; DTSC 1992	Constant	Value: 350 days/year Rationale: USEPA 1997; DTSC 1992
Exposure Duration (ED)	Value: 9 years Rationale: Average residence time, USEPA 1997	Selected exposure duration from distribution given below, less 6 years for child exposure (truncated at 0 years) Lognormal mean: 9.37 years standard deviation: 2.52 years Source: CalTOX 1994[1]	Value: 24 years (30-year lifetime minus 6 years as child) Rationale: 95th percentile value for residence time, USEPA 1997
Averaging Time (AT)	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration or 9 years (3,285 days) Rationale: USEPA 1997	Carcinogenic Effects: Constant at 75 years Noncarcinogenic Effects: Co-vary with exposure duration	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration or 24 years (8,760 days) Rationale: USEPA 1997

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EXPOSURE ASSESSMENT PARAMETERS FOR AN OFFSITE RESIDENTIAL ADULT – AFTER PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
Inhalation of Vapors:			
Breathing Rate (BR)	Value: 0.43 m^3/hr Rationale: Mean value for resting inhalation rate; CalTOX 1994	Lognormal mean: 0.43 m^3/hr standard deviation: 0.09 m^3/hr Source: Resting inhalation rate; CalTOX 1994[1]	Value: 0.55 m^3/hour Rationale: Recommended value for RME (midpoint between male and female values), USEPA 1997
Hours of day spent in or near home (EF_f)	16.3 hours/day Rationale: CalTOX average	Lognormal mean: 16.3 hours/day standard deviation: 2.24 hours/day Source: CalTOX 1994[1]	24 hours./day Rationale: Maximum hours in a day

[1] CalTOX computer model version 1994.
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EXPOSURE ASSESSMENT PARAMETERS FOR AN OFFSITE LIGHT INDUSTRIAL/COMMERCIAL WORKER – AFTER PROPERTY REDEVELOPMENT

Parameter	Central Tendency Exposure (CTE) Deterministic Risk Estimate	Exposure Distribution for Probabilistic Risk Estimation	Reasonable Maximum Exposure (RME) Deterministic Risk Estimate
General Parameters:			
Body Weight (BW)	Value: 70 kg Rationale: Average body weight, USEPA 1997	Lognormal mean: 71 kg standard deviation: 14.2 Source: CalTOX 1994[1]	Value: 70 kg Rationale: Average body weight, USEPA 1997
Exposure Frequency (EF)	Value: 8 hrs/d, 219 d/yr Rationale: DTSC 1999	Constant	Value: 8 hrs/d, 250 d/yr Rationale: USEPA 1997
Exposure Duration (ED)	Value: 9 years Rationale: DTSC 1999	Continuous variable across age-specific occupational tenure reported by Carey (1988) as presented by USEPA (1997)	Value: 25 years Rationale: DTSC 1999
Averaging Time (AT)	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: USEPA 1997	Carcinogenic Effects: Constant at 75 years Noncarcinogenic Effects: Co-vary with exposure duration	Value: Carcinogenic Effects: 75 years (27,375 days) Noncarcinogenic Effects: AT = Exposure duration Rationale: USEPA 1997
Inhalation of Indoor Vapors or Outdoor Particulates:			
Breathing Rate (BR)	Value: 1.3 m^3/hr Rationale: Hourly average for outdoor workers, USEPA 1997	Lognormal mean: 1.44 m^3/hr standard deviation: 0.66 m^3/hr Rationale: General construction workers and laborers reported by Linn et al. (1993) as presented by USEPA (1997)	Value: 2.0 m^3/hour Rationale: Midpoint between moderate and heavy activity values, USEPA 1997

[1] CalTOX computer model version 1994.
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SECTION 8
HUMAN HEALTH TOXICITY ASSESSMENT

The relationship between the chemical intake and the probability of an adverse health effect in the exposed population is characterized in the toxicity assessment portion of the human health risk assessment. This section presents the dose-response assessment for the chemicals identified for chemical analysis during the Phase II investigations. Chemicals have been identified as having carcinogenic and/or noncarcinogenic toxicity criteria in accordance with Cal-EPA and DTSC guidelines (Cal-EPA 1997; DTSC 1992, 1994). The chemical-specific toxicological criteria (i.e., reference doses and slope factors) for each COPC will be presented in the risk assessment reports in tabular format. Specific reference sources for the toxicity criteria will be cited.

Toxicity criteria for chemicals to be analyzed during the Phase II investigations are presented in Tables 8-1 and 8-2. Chronic toxicity criteria are presented in Table 8-1 and subchronic toxicity criteria are presented in Table 8-2. Since hazard identification for each of the exposure areas has not been completed, these lists are provided based on the chemicals that may be detected, and may not be complete or may include chemicals that will not be selected as COPCs.

8.1 NONCARCINOGENIC HEALTH EFFECTS

It is widely accepted that noncarcinogenic health effects from chemical substances occur only after a threshold dose or intake is reached. For the purposes of establishing health criteria, this threshold dose is usually estimated from the no-observed-adverse-effect-level (NOAEL) or the lowest-observed-adverse-effect-level (LOAEL) determined from chronic or subchronic animal studies. The NOAEL is defined as the highest dose at which no adverse effects are observed, while the LOAEL is defined as the lowest dose at which adverse effects are observed.

Safety factors are applied to the NOAEL or LOAEL observed in animal studies or human epidemiological studies to establish "reference doses" (RfDs). An RfD is an estimate of a dose level that is not expected to result in adverse health effects in persons exposed for a lifetime, even among the most sensitive members of the population (USEPA 1989). A subchronic RfD is defined as an acceptable estimated daily exposure over a portion of a lifetime (2 weeks to 7 years), while a chronic RfD is defined as an acceptable daily

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exposure over an entire lifetime (greater than 7 years) (USEPA 1989). The RfD is used in the risk characterization (Section 10) to estimate the potential for noncarcinogenic health hazards.

8.2 Carcinogenic Health Effects

Regulatory agencies have generally assumed that carcinogenic agents should not be considered to have toxicological thresholds. In short, the dose-response curve used for regulation of carcinogens only predicts zero risk when there is zero dose (i.e., for all doses greater than zero, some risk is assumed to be present). Cancer risks from potential human exposures to carcinogenic chemicals are modeled mathematically using either animal or human data. USEPA generally uses the linearized multistage model for low-dose extrapolation. The model is considered to be one of the most conservative models that may be applied and has been recognized by USEPA to overpredict incremental cancer risks.

Cancer risks for exposure to carcinogens are defined in terms of upper bounds on probabilities. The probabilities identify the likelihood of a carcinogenic response in an individual that receives a given dose of a particular chemical (based on mathematical modeling of the animal or human data). These probabilities are expressed in terms of the slope factor (SF). The SF represents the upper bound on the probability of a carcinogenic response (per unit dose) and is usually expressed as milligrams per kilogram per day $(mg/kg\text{-}day)^{-1}$. The slope factor multiplied by the predicted chemical dose intake, in units of mg/kg-day, provides an estimate of the incremental upperbound cancer risk.

8.3 Chemical-Specific Toxicity Criteria

When available, Cal-EPA toxicity criteria will be used to estimate cancer risks and noncancer HIs. For chemicals for which Cal-EPA has not developed toxicity criteria, toxicity values will be obtained from USEPA and other sources as necessary. The hierarchy of sources for toxicological criteria is as follows:

1. Cal-EPA's Office of Environmental Health Hazard Assessment, published criteria (Cal-EPA 1994, 1997)
2. USEPA Integrated Risk Information System (IRIS)
3. USEPA Health Effects Assessment Summary Table (HEAST)

4. USEPA criteria documents
5. Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles
6. USEPA Environmental Criteria and Assessment Office (ECAO)
7. Other sources

Professional judgments on toxicity factors may include (1) deriving new RfDs from literature information and standard uncertainty factors when acceptable standards are not available, (2) applying route-to-route extrapolations where data indicate similar toxic endpoints would exist for different exposure routes, and (3) extrapolation from chronic RfDs to subchronic RfDs, when subchronic RfDs are not available, by application of a ten-fold uncertainty factor, and (4) application of structure-activity assumptions to justify utilization of a surrogate chemical for estimating the toxicity of a chemical for which insufficient toxicity data are available. An example of this last approach is presented in Table 8-1, where the RfD for pyrene (a low molecular weight PAH) is provided for acenaphthylene and phenanthrene, which are also low molecular weight PAHs.

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Table 8-1 (Page 1 of 7)
CHRONIC TOXICITY VALUES

CAS Number	Chemical	CSF (oral) $(mg/kg\text{-}day)^{-1}$	References	CSF (inh) $(mg/kg\text{-}day)^{-1}$	References	Chronic RfD (oral) (mg/kg-day)	References	Chronic RfD (inh) (mg/kg-day)	References
Metals									
7429-90-5	ALUMINUM	na		na		1.8E-01	b	1.4E-03	b
7440-36-0	ANTIMONY	na		na		4.3E-04	b	na	
7440-38-2	ARSENIC	1.5E+00	a	1.2E+01	b	3.0E-04	a	na	
7440-39-3	BARIUM	na		na		2.1E-02	b	1.4E-04	b
7440-41-7	BERYLLIUM	na		8.4E+00	b	5.4E-04	b	5.7E-06	b
7440-42-8	BORON	na		na		9.0E-02	a	5.7E-03	b
7440-43-9	CADMIUM	3.8E-01	b	1.5E+01	b	5.0E-04	a	na	
7440-47-3	CHROMIUM (Total)	1.9E-01	b	5.1E+02	b	na		na	
	CHROMIUM III	na		na		na		na	
	CHROMIUM IV	1.9E-01	b	5.1E+02	b	3.0E-03	a	na	
7440-48-4	COBALT	na		na		6.0E-02	c	na	
7440-50-8	COPPER	na		na		1.9E-02	b	na	
7439-92-1	LEAD	8.5E-03	b	4.2E-02	b	na			
7439-96-5	MANGANESE	na		na		2.4E-02	a	1.4E-05	b
7487-94-7	MERCURY	na		na		3.0E-04	a	2.6E-05	b
7439-98-7	MOLYBDENUM	na		na		5.0E-03	d	na	
7440-02-0	NICKEL	na		9.1E-01	b	2.0E-02	a	na	
7782-49-2	SELENIUM	na		na		2.7E-03	b	na	
7440-22-4	SILVER	na		na		5.0E-03	a	na	
7440-28-0	THALLIUM	na		na		8.0E-05	a	na	
7440-62-2	VANADIUM	na		na		7.0E-03	d	na	
7440-66-6	ZINC	na		na		3.0E-01	a	na	
Polychlorinated Biphenyls (PCBs)									
12674-11-2	AROCLOR-1016	5.0E+00	b	2.0E+00	b	7.0E-05	a	7.0E-05	b
11104-28-2	AROCLOR-1221	5.0E+00	b	2.0E+00	a	2.0E-05	e	2.0E-05	b
11141-16-5	AROCLOR-1232	5.0E+00	b	2.0E+00	a	2.0E-05	e	2.0E-05	b
53469-21-9	AROCLOR-1242	5.0E+00	b	2.0E+00	a	2.0E-05	e	2.0E-05	b
12672-29-6	AROCLOR-1248	5.0E+00	b	2.0E+00	a	2.0E-05	e	2.0E-05	b
11097-69-1	AROCLOR-1254	5.0E+00	b	2.0E+00	a	2.0E-05	a	2.0E-05	b
11096-82-5	AROCLOR-1260	5.0E+00	b	2.0E+00	a	2.0E-05	e	2.0E-05	b

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Table 8-1 (Page 2 of 7)
CHRONIC TOXICITY VALUES

CAS Number	Chemical	CSF (oral) $(mg/kg\text{-}day)^{-1}$	References	CSF (inh) $(mg/kg\text{-}day)^{-1}$	References	Chronic RfD (oral) (mg/kg-day)	References	Chronic RfD (inh) (mg/kg-day)	References
Polycyclic Aromatic Hydrocarbons (PAHs)									
83-32-9	ACENAPHTHENE	na		na		6.0E-02	a	6.0E-02	b
208-96-8	ACENAPHTHYLENE	na		na		3.0E-02	d	3.0E-02	b
120-12-7	ANTHRACENE	na		na		3.0E-01	a	3.0E-01	b
56-55-3	BENZO(A)ANTHRACENE	1.2E+00	b	3.9E-01	b	na		na	
50-32-8	BENZO(A)PYRENE	1.2E+01	b	3.9E+00	b	na		na	
205-99-2	BENZO(B)FLUORANTHENE	1.2E+00	b	3.9E-01	b	na		na	
191-24-2	BENZO(G,H,I)PERYLENE	na		na		2.0E-02	d	8.6E-04	b
207-08-9	BENZO(K)FLUORANTHENE	1.2E+00	b	3.9E-01	b	na		na	
218-01-9	CHRYSENE	1.2E-01	b	3.9E-02	b	na		na	
53-70-3	DIBENZ(A,H)ANTHRACENE	4.1E+00	b	4.1E+00	b	na		na	
206-44-0	FLUORANTHENE	na		na		4.0E-02	a	4.0E-02	b
86-73-7	FLUORENE	na		na		4.0E-02	a	4.0E-02	b
193-39-5	INDENO(1,2,3-CD)PYRENE	1.2E+00	b	3.9E-01	b	na		na	
91-20-3	NAPHTHALENE	na		na		2.0E-02	a	8.6E-04	b
85-01-8	PHENANTHRENE	na		na		3.0E-02	a	3.0E-02	b
129-00-0	PYRENE	na		na		3.0E-02	a	3.0E-02	b
Semivolatile Organic Chemicals (SVOCs)									
120-82-1	1,2,4-TRICHLOROBENZENE	3.6E-03	b	na		1.0E-02	a	1.0E-02	b
95-50-1	1,2-DICHLOROBENZENE	na		na		9.0E-02	a	6.0E-02	b
541-73-1	1,3-DICHLOROBENZENE	na		na		9.0E-04	c	9.0E-04	b
106-46-7	1,4-DICHLOROBENZENE	5.4E-03	b	4.0E-02	b	1.1E-01	b	2.0E-01	b
95-95-4	2,4,5-TRICHLOROPHENOL	na		na		1.0E-01	a	1.0E-01	b
88-06-2	2,4,6-TRICHLOROPHENOL	7.0E-02	b	7.0E-02	b	na		na	
120-83-2	2,4-DICHLOROPHENOL	na		na		3.0E-03	a	3.0E-03	b
105-67-9	2,4-DIMETHYLPHENOL	na		na		2.0E-02	a	2.0E-02	b
51-28-5	2,4-DINITROPHENOL	na		na		2.0E-03	a	2.0E-03	b
121-14-2	2,4-DINITROTOLUENE	3.1E-01	b	3.1E-01	b	2.0E-03	a	2.0E-03	b
606-20-2	2,6-DINITROTOLUENE	na		na		1.0E-03	d	1.0E-03	b
91-58-7	2-CHLORONAPHTHALENE	na		na		8.0E-02	d	8.0E-02	b
95-57-8	2-CHLOROPHENOL	na		na		5.0E-03	a	5.0E-03	b
91-57-6	2-METHYLNAPHTHALENE	na		na		2.0E-02	d	8.6E-04	b

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Table 8-1 (Page 3 of 7)
CHRONIC TOXICITY VALUES

CAS Number	Chemical	CSF (oral) $(mg/kg\text{-}day)^{-1}$	References	CSF (inh) $(mg/kg\text{-}day)^{-1}$	References	Chronic RfD (oral) (mg/kg-day)	References	Chronic RfD (inh) (mg/kg-day)	References
95-48-7	2-METHYLPHENOL	na		na		5.0E-02	a	5.0E-02	b
91-59-8	2-NAPHTHYLAMINE	na		na		2.5E-02	d	2.5E-02	b
88-74-4	2-NITROANILINE	na		na		5.7E-05	d	5.7E-05	b
88-75-5	2-NITROPHENOL	na		na		8.0E-03	d	8.0E-03	b
91-94-1	3,3'-DICHLOROBENZIDINE	1.2E+00	b	1.2E+00	b	na		na	
99-09-2	3-NITROANILINE	na		na		5.7E-05	d	5.7E-05	b
534-52-1	4,6-DINITRO-2-METHYLPHENOL	na		na		2.0E-03	d	2.0E-03	b
101-55-3	4-BROMOPHENYLPHENYL ETHER	na		na		na		na	
59-50-7	4-CHLORO-3-METHYLPHENOL	na		na		5.0E-03	d	5.0E-03	b
106-47-8	4-CHLOROANILINE	na		na		4.0E-03	a	4.0E-03	b
7005-72-3	4-CHLOROPHENYL-PHENYL ETHER	na		na		na		na	
106-44-5	4-METHYLPHENOL	na		na		5.0E-03	d	5.0E-03	b
100-01-6	4-NITROANILINE	na		na		5.7E-05	d	5.7E-05	b
100-02-7	4-NITROPHENOL	na		na		8.0E-03	e	8.0E-03	b
62-53-3	ANILINE	5.7E-03	a	5.7E-03	a	7.0E-03	e	2.9E-04	b
92-87-5	BENZIDINE	5.0E+02	b	5.0E+02	b	3.0E-03	a	3.0E-03	b
65-85-0	BENZOIC ACID	na		na		4.0E+00	a	4.0E+00	b
100-51-6	BENZYL ALCOHOL	na		na		3.0E-01	d	3.0E-01	b
111-91-1	BIS(2-CHLOROETHOXY)METHANE	na		na		na		na	
111-44-4	BIS(2-CHLOROETHYL)ETHER	2.5E+00	b	2.5E+00	b	na		na	
108-60-1	BIS(2-CHLOROISOPROPYL)ETHER	7.0E-02	d	3.5E-02	d	4.0E-02	a	4.0E-02	b
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	3.0E-03	b	8.4E-03	b	2.0E-02	a	2.0E-02	b
85-68-7	BUTYLBENZYLPHTHALATE	na		na		2.0E-01	a	2.0E-01	b
132-64-9	DIBENZOFURAN	na		na		4.0E-03	a	4.0E-03	b
84-66-2	DIETHYLPHTHALATE	na		na		8.0E-01	a	8.0E-01	b
131-4-3	DIMETHYPHTHALATE	na		na		na		na	
84-74-2	DI-N-BUTYLPHTHALATE	na		na		1.0E-01	a	1.0E-01	b
117-84-0	DI-N-OCTYLPHTHALATE	na		na		2.0E-02	d	2.0E-02	b
118-74-1	HEXACHLOROBENZENE	1.8E+00	b	1.8E+00	b	8.0E-04	a	8.0E-04	b
87-68-3	HEXACHLOROBUTADIENE	7.8E-02	a	7.7E-02	b	2.0E-04	d	2.0E-04	b
77-47-4	HEXACHLOROCYCLOPENTADIENE	na		na		7.0E-03	a	7.0E-03	b
67-72-1	HEXACHLOROETHANE	3.9E-02	b	3.9E-02	b	1.0E-03	a	1.0E-03	b
78-59-1	ISOPHORONE	9.5E-04	a	9.5E-04	a	2.0E-01	a	2.0E-01	b

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CHRONIC TOXICITY VALUES

CAS Number	Chemical	CSF (oral) $(mg/kg\text{-}day)^{-1}$	References	CSF (inh) $(mg/kg\text{-}day)^{-1}$	References	Chronic RfD (oral) (mg/kg-day)	References	Chronic RfD (inh) (mg/kg-day)	References
98-95-3	NITROBENZENE	na		na		5.0E-04	a	6.0E-04	b
62-75-9	N-NITROSODIMETHYLAMINE	1.6E+01	b	1.6E+01	b	na		na	
621-64-7	N-NITROSO-DI-N-PROPYLAMINE	7.0E+00	a	7.0E+00	a	na		na	
86-30-6	N-NITROSODIPHENYLAMINE	9.0E-03	b	9.0E-03	b	na		na	
87-86-5	PENTACHLOROPHENOL	8.1E-02	b	1.8E-02	b	3.0E-02	a	3.0E-02	b
108-95-2	PHENOL	na		na		6.0E-01	a	6.0E-01	b
110-86-1	PYRIDINE	na		na		1.0E-03	a	1.0E-03	b
Volatile Organic Chemicals (VOCs)								na	
71-43-2	BENZENE	1.0E-01	b	1.0E-01	b	3.0E-03	e	1.7E-02	b
100-41-4	ETHYLBENZENE	na		na		1.0E-01	a	5.7E+00	b
1634-04-4	METHYL-T-BUTYL ETHER	1.8E-03	b	na		5.0E-03	b	8.6E-01	b
1330-20-7	M-XYLENE & P-XYLENE	na		na		2.0E+00	a	2.0E+00	b
1330-20-7	O-XYLENE	na		na		2.0E+00	a	2.0E+00	b
108-88-3	TOLUENE	na		na		2.0E-01	a	3.0E-02	b
1330-20-7	XYLENES (TOTAL)	na		na		2.0E+00	a	2.0E+00	b
630-20-6	1,1,1,2-TETRACHLOROETHANE	2.6E-02	a	2.6E-02	a	3.0E-02	a	3.0E-02	b
71-55-6	1,1,1-TRICHLOROETHANE	na		na		9.0E-01	b	2.9E-01	b
79-34-5	1,1,2,2-TETRACHLOROETHANE	2.7E-01	b	2.0E-01	a	1.4E-04	b	6.0E-02	b
79-00-5	1,1,2-TRICHLOROETHANE	7.2E-02	b	1.7E+01	b	4.0E-03	a	4.0E-03	b
75-34-3	1,1-DICHLOROETHANE	5.7E-03	b	5.7E-03	b	1.0E-01	d	1.0E-01	b
75-35-4	1,1-DICHLOROETHENE	6.0E-01	a	1.8E-01	b	9.0E-03	a	9.0E-03	b
563-58-6	1,1-DICHLOROPROPENE	9.1E-02	b	5.5E-02	b	3.0E-04	d	6.0E-03	b
87-61-6	1,2,3-TRICHLOROBENZENE	3.6E-03	b	na		1.0E-02	d	1.0E-02	b
96-18-4	1,2,3-TRICHLOROPROPANE	7.0E+00	d	7.0E+00	d	6.0E-03	a	5.0E-03	b
120-82-1	1,2,4-TRICHLOROBENZENE	3.6E-03	b	na		1.0E-02	a	1.0E-02	b
95-63-6	1,2,4-TRIMETHYLBENZENE	na		na		5.0E-02	c	1.7E-03	b
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	7.0E+00	b	7.0E+00	b	5.7E-05	a	5.7E-05	b
106-93-4	1,2-DIBROMOETHANE	3.6E+00	b	2.5E-01	b	5.7E-05	d	5.7E-05	b
95-50-1	1,2-DICHLOROBENZENE	na		na		9.0E-02	a	6.0E-02	b
107-06-2	1,2-DICHLOROETHANE	4.7E-02	b	7.0E-02	b	3.0E-02	c	1.4E-03	b
78-87-5	1,2-DICHLOROPROPANE	3.6E-02	b	3.6E-02	b	1.1E-03	a	1.0E-03	b
108-67-8	1,3,5-TRIMETHYLBENZENE	na		na		5.0E-02	c	1.7E-03	b

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CHRONIC TOXICITY VALUES

CAS Number	Chemical	CSF (oral) $(mg/kg\text{-}day)^{-1}$	References	CSF (inh) $(mg/kg\text{-}day)^{-1}$	References	Chronic RfD (oral) (mg/kg-day)	References	Chronic RfD (inh) (mg/kg-day)	References
541-73-1	1,3-DICHLOROBENZENE	na		na		9.0E-04	c	9.0E-04	b
106-46-7	1,4-DICHLOROBENZENE	5.4E-03	b	4.0E-02	b	1.1E-01	b	2.0E-01	b
123-91-1	1,4-DIOXANE	2.7E-02	b	2.7E-02	b	na		na	
594-20-7	2,2-DICHLOROPROPANE	3.6E-02	b	3.6E-02	b	1.1E-03	d	1.0E-03	b
78-93-3	2-BUTANONE(MEK)	na		na		6.0E-01	a	4.4E-01	b
110-75-8	2-CHLOROETHYLVINYL ETHER	na		na		na		na	
95-49-8	2-CHLOROTOLUENE	na		na		2.0E-02	d	2.0E-02	b
591-78-6	2-HEXANONE	na		na		8.0E-02	d	2.3E-02	b
106-43-4	4-CHLOROTOLUENE	na		na		2.0E-02	d	2.0E-02	b
108-10-1	4-METHYL-2-PENTANONE(MIBK)	na		na		8.0E-02	d	2.3E-02	b
67-64-1	ACETONE	na		na		1.0E-01	a	1.0E-01	b
75-05-8	ACETONITRILE	na		na		6.0E-03	a	1.7E-02	b
107-02-8	ACROLEIN	na		na		2.0E-02	d	5.7E-06	b
107-13-1	ACRYLONITRILE	1.0E+00	b	1.0E+00	b	1.0E-03	d	5.7E-04	b
107-05-1	ALLYL CHLORIDE	2.1E-02	b	2.1E-02	b	5.0E-02	d	2.9E-04	b
100-44-7	BENZYL CHLORIDE	1.0E-01	b	1.7E-01	a	na		na	
108-86-1	BROMOBENZENE	na		na		2.0E-02	c	2.9E-03	b
74-97-5	BROMOCHLOROMETHANE	1.3E-01	b	1.3E-01	b	2.0E-02	d	2.0E-02	b
75-27-4	BROMODICHLOROMETHANE	1.3E-01	b	1.3E-01	b	2.0E-02	a	2.0E-02	b
75-25-2	BROMOFORM	7.9E-03	a	3.9E-03	b	2.0E-02	a	2.0E-02	b
74-83-9	BROMOMETHANE	na		na		1.4E-03	a	1.0E-03	b
75-15-0	CARBON DISULFIDE	na		na		1.0E-01	a	3.0E-03	b
56-23-5	CARBON TETRACHLORIDE	1.5E-01	b	1.5E-01	b	7.0E-04	a	7.0E-04	b
108-90-7	CHLOROBENZENE	na		na		2.0E-02	a	6.0E-03	b
75-00-3	CHLOROETHANE	2.9E-03	c	2.9E-03	c	4.0E-01	c	2.9E+00	b
67-66-3	CHLOROFORM	3.1E-02	b	1.9E-02	b	1.0E-02	a	1.0E-02	b
74-87-3	CHLOROMETHANE	1.3E-02	d	6.3E-03	d	1.6E-02	b	8.6E-02	b
126-99-8	CHLOROPRENE	na		na		2.0E-02	d	2.0E-03	b
156-59-2	CIS-1,2-DICHLOROETHENE	4.7E-02	b	7.0E-02	b	8.5E-04	b	1.0E-02	b
10061-01-5	CIS-1,3-DICHLOROPROPENE	9.1E-02	b	5.5E-02	b	3.0E-04	a	6.0E-03	b
108-94-1	CYCLOHEXANONE	na		na		5.0E+00	a	5.0E+00	b
124-48-1	DIBROMOCHLOROMETHANE	9.4E-02	b	9.4E-02	b	2.0E-02	a	2.0E-02	b
75-71-8	DICHLORODIFLUOROMETHANE (Freon 12)	na		na		1.5E-01	b	5.7E-02	b

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CHRONIC TOXICITY VALUES

CAS Number	Chemical	CSF (oral) $(mg/kg\text{-}day)^{-1}$	References	CSF (inh) $(mg/kg\text{-}day)^{-1}$	References	Chronic RfD (oral) (mg/kg-day)	References	Chronic RfD (inh) (mg/kg-day)	References
64-17-5	ETHANOL	na		na		na		na	
87-68-3	HEXACHLOROBUTADIENE	7.8E-02	a	7.7E-02	b	2.0E-04	d	2.0E-04	b
74-88-4	IODOMETHANE	na		na		na		na	
78-83-1	ISOBUTYL ALCOHOL	na		na		3.0E-01	a	3.0E-01	b
98-82-8	ISOPROPYLBENZENE	na		na		1.0E-01	a	1.1E-01	b
126-98-7	METHACRYLONITRILE	na		na		1.0E-04	a	2.0E-04	b
80-62-6	METHYL METHACRYLATE	na		na		1.4E+00	a	2.0E-01	b
75-09-2	METHYLENE CHLORIDE	1.4E-02	b	3.5E-03	b	6.0E-02	a	1.4E-02	b
1634-04-4	METHYL-T-BUTYL ETHER	1.8E-03	b	na		5.0E-03	b	8.6E-01	b
104-51-8	N-BUTYLBENZENE	na		na		1.0E-02	c	1.0E-02	b
103-65-1	N-PROPYLBENZENE	na		na		1.0E-02	c	1.0E-02	b
76-01-7	PENTACHLOROETHANE	3.9E-02	b	3.9E-02	b	1.0E-03	d	1.0E-03	b
99-87-6	P-ISOPROPYL TOLUENE	na		na		2.0E+00	d	2.0E+00	b
107-12-0	PROPIONITRILE	na		na		6.0E-03	d	1.7E-02	b
135-9-88	SEC-BUTYLBENZENE	na		na		1.0E-02	c	1.0E-02	b
100-42-5	STYRENE	na		na		2.0E-01	a	3.0E-01	b
98-06-6	T-BUTYLBENZENE	na		na		1.0E-02	c	1.0E-02	b
127-18-4	TETRACHLOROETHENE (PCE)	5.1E-02	b	2.1E-02	b	1.0E-02	a	1.0E-02	b
109-99-9	TETRAHYDROFURAN	7.6E-03	c	6.8E-03	c	2.1E-01	c	8.6E-02	b
156-60-5	TRANS-1,2-DICHLOROETHENE	4.7E-02	b	7.0E-02	b	2.0E-02	a	2.0E-02	b
10061-02-6	TRANS-1,3-DICHLOROPROPENE	9.1E-02	b	5.5E-02	b	3.0E-04	a	6.0E-03	b
110-57-6	TRANS-1,4-DICHLORO-2-BUTENE	9.3E+00	d	9.3E+00	d	na		na	
79-01-6	TRICHLOROETHENE (TCE)	1.5E-02	b	1.0E-02	b	6.0E-03	a	6.0E-03	b
75-69-4	TRICHLOROFLUOROMETHANE	na		na		1.9E-01	b	2.0E-01	b
-na-	TRIHALOMETHANES (TOTAL)	na		na		na		na	
108-05-4	VINYL ACETATE	na		na		1.0E+00	d	5.7E-02	b
75-01-4	VINYL CHLORIDE	2.7E-01	b	2.7E-01	b	na		na	

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CHRONIC TOXICITY VALUES

CAS Number	Chemical	CSF (oral) $(mg/kg\text{-}day)^{-1}$	References	CSF (inh) $(mg/kg\text{-}day)^{-1}$	References	Chronic RfD (oral) (mg/kg-day)	References	Chronic RfD (inh) (mg/kg-day)	References

Key:
PRG= Preliminary Remediation Goals
CAS= Chemical Abstracts Service
USEPA= U.S. Environmental Protection Agency
CSF= Cancer Slope Factor
RfD= Reference Dose
inh= Inhalation
Cal-EPA= California Environmental Protection Agency
mg/kg= milligrams per kilogram
na= regulatory approved toxicity criteria not available or not applicable

Subchronic Oral Toxicity Values selected or derived with the following priorities:

1. Cal-EPA Office of Environmental Health Hazard Asssessment (OEHHA)
2. USEPA Integrated Risk Information System (IRIS)
3. USEPA National Center for Environmental Assessment (NCEA)
4. USEPA. 1997. Health Effects Summary Tables.

References

a. USEPA Integrated Risk Information System (IRIS)
b. Cal-EPA Office of Environmental Health Hazard Asssessment (OEHHA)
c. USEPA National Center for Environmental Assessment (NCEA)
d. USEPA. 1997. Health Effects Summary Tables.
e. USEPA has only developed reference doses for Aroclors 1016 and 1254. For the purpose of this RAWP, the chronic reference dose for Aroclor 1254 was applied to all Arcoclor mixtures, except Aroclor 1016.

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Table 8-2 (Page 1 of 5)
SUBCHRONIC TOXICITY VALUES

CAS Number	Chemical	Subchronic RfD (oral) (mg/kg-day)	References	Subchronic RfD (inh) (mg/kg-day)	References
Metals					
7429-90-5	ALUMINUM	2.E+00	a	1.4E-02	d
7440-36-0	ANTIMONY	4.E-04	b	na	
7440-38-2	ARSENIC	3.E-04	b	na	
7440-39-3	BARIUM	7.E-02	b	1.4E-03	d
7440-41-7	BERYLLIUM	5.E-03	b	5.7E-05	d
7440-42-8	BORON	9.E-01	c	5.7E-02	d
7440-43-9	CADMIUM	5.E-03	c	na	
7440-47-3	CHROMIUM (TOTAL)	na		na	
	CHROMIUM III	1.E+00	b	na	
	CHROMIUM IV	2.E-02	b	na	
7440-48-4	COBALT	na		na	
7440-50-8	COPPER	2.E-01	a	na	
7439-92-1	LEAD	na		na	
7439-96-5	MANGANESE	1.4.E-01	b	1.4E-04	d
7487-94-7	MERCURY	3.E-04	b	2.6E-04	d
7439-98-7	MOLYBDENUM	5.E-03	b	na	
7440-02-0	NICKEL	2.E-02	b	na	
7782-49-2	SELENIUM	5.E-03	b	na	
7440-22-4	SILVER	5.E-03	b	na	
7440-28-0	THALLIUM	8.E-04	b	na	
7440-62-2	VANADIUM	7.E-03	b	na	
7440-66-6	ZINC	3.E-01	b	na	
Polychlorinated Biphenyls (PCBs)					
12674-11-2	AROCLOR-1016	7.E-04	b	7.0E-04	d
11104-28-2	AROCLOR-1221	5.E-05	b	2.0E-04	d
11141-16-5	AROCLOR-1232	5.E-05	b	2.0E-04	d
53469-21-9	AROCLOR-1242	5.E-05	b	2.0E-04	d
12672-29-6	AROCLOR-1248	5.E-05	b	2.0E-04	d
11097-69-1	AROCLOR-1254	5.E-05	b	2.0E-04	d
11096-82-5	AROCLOR-1260	5.E-05	b	2.0E-04	d
Polycyclic Aromatic Hydrocarbons (PAHs)					
83-32-9	ACENAPHTHENE	6.E-01	b	6.0E-01	d
208-96-8	ACENAPHTHYLENE	3.E-01	c	3.0E-01	d
120-12-7	ANTHRACENE	3.E+00	b	3.0E+00	d
56-55-3	BENZO(A)ANTHRACENE	na		na	
50-32-8	BENZO(A)PYRENE	na		na	
205-99-2	BENZO(B)FLUORANTHENE	na		na	
191-24-2	BENZO(G,H,I)PERYLENE	2.E-01	c	8.6E-03	d
207-08-9	BENZO(K)FLUORANTHENE	na		na	
218-01-9	CHRYSENE	na		na	
53-70-3	DIBENZ(A,H)ANTHRACENE	na		na	
206-44-0	FLUORANTHENE	4.E-01	b	4.0E-01	d
86-73-7	FLUORENE	4.E-01	b	4.0E-01	d
193-39-5	INDENO(1,2,3-CD)PYRENE	na		na	
91-20-3	NAPHTHALENE	2.E-01	c	8.6E-03	d
85-01-8	PHENANTHRENE	3.E-01	c	3.0E-01	d
129-00-0	PYRENE	3.E-01	b	3.0E-01	d

Table 8-2 (Page 2 of 5)
SUBCHRONIC TOXICITY VALUES

CAS Number	Chemical	Subchronic RfD (oral) (mg/kg-day)	References	Subchronic RfD (inh) (mg/kg-day)	References
Semivolatile Organic Chemicals (SVOCs)					
120-82-1	1,2,4-TRICHLOROBENZENE	1.E-02	b	1.0E-01	d
95-50-1	1,2-DICHLOROBENZENE	9.E-01	c	6.0E-01	d
541-73-1	1,3-DICHLOROBENZENE	9.E-03	c	9.0E-03	d
106-46-7	1,4-DICHLOROBENZENE	1.E+00	a	7.1E-01	e
95-95-4	2,4,5-TRICHLOROPHENOL	1.E+00	b	1.0E+00	d
88-06-2	2,4,6-TRICHLOROPHENOL	na		na	
120-83-2	2,4-DICHLOROPHENOL	3.E-03	b	3.0E-02	d
105-67-9	2,4-DIMETHYLPHENOL	2.E-01	b	2.0E-01	d
51-28-5	2,4-DINITROPHENOL	2.E-03	b	2.0E-02	d
121-14-2	2,4-DINITROTOLUENE	2.E-03	b	2.0E-02	d
606-20-2	2,6-DINITROTOLUENE	1.E-02	b	1.0E-02	d
91-58-7	2-CHLORONAPHTHALENE	8.E-01	c	8.0E-01	d
95-57-8	2-CHLOROPHENOL	5.E-02	b	5.0E-02	d
91-57-6	2-METHYLNAPHTHALENE	2.E-01	c	8.6E-03	d
95-48-7	2-METHYLPHENOL	5.E-01	c	5.0E-01	d
91-59-8	2-NAPHTHYLAMINE	3.E-01	c	2.5E-01	d
88-74-4	2-NITROANILINE	2.E-03	b	5.7E-04	d
88-75-5	2-NITROPHENOL	8.E-02	c	8.0E-02	d
91-94-1	3,3'-DICHLOROBENZIDINE	na		na	
99-09-2	3-NITROANILINE	6.E-04	c	5.7E-04	d
534-52-1	4,6-DINITRO-2-METHYLPHENOL	2.E-02	c	2.0E-02	d
101-55-3	4-BROMOPHENYLPHENYL ETHER	na		na	
59-50-7	4-CHLORO-3-METHYLPHENOL	5.E-02	c	5.0E-02	d
106-47-8	4-CHLOROANILINE	4.E-03	b	4.0E-02	d
7005-72-3	4-CHLOROPHENYL-PHENYL ETHER	na		na	
106-44-5	4-METHYLPHENOL	5.E-02	c	5.0E-02	d
100-01-6	4-NITROANILINE	6.E-04	c	5.7E-04	d
100-02-7	4-NITROPHENOL	8.E-02	c	8.0E-02	d
62-53-3	ANILINE	7.E-02	c	2.9E-03	e
92-87-5	BENZIDINE	3.E-03	b	3.0E-02	d
65-85-0	BENZOIC ACID	4.E+00	b	4.0E+01	d
100-51-6	BENZYL ALCOHOL	3.E+00	c	3.0E+00	d
111-91-1	BIS(2-CHLOROETHOXY)METHANE	na		na	
111-44-4	BIS(2-CHLOROETHYL)ETHER	na		na	
108-60-1	BIS(2-CHLOROISOPROPYL)ETHER	4.E-02	b	4.0E-01	d
117-81-7	BIS(2-ETHYLHEXYL)PHTHALATE	2.E-01	c	2.0E-01	d
85-68-7	BUTYLBENZYLPHTHALATE	2.E+00	b	2.0E+00	d
132-64-9	DIBENZOFURAN	4.E-02	c	4.0E-02	d
84-66-2	DIETHYLPHTHALATE	8.E+00	b	8.0E+00	d
131-4-3	DIMETHYPHTHALATE	na		na	
84-74-2	DI-N-BUTYLPHTHALATE	1.E+00	b	1.0E+00	d
117-84-0	DI-N-OCTYLPHTHALATE	na	c	2.0E-01	d
118-74-1	HEXACHLOROBENZENE	8.E-03	c	8.0E-03	d
87-68-3	HEXACHLOROBUTADIENE	2.E-03	c	2.0E-03	d
77-47-4	HEXACHLOROCYCLOPENTADIENE	7.E-02	b	7.0E-02	d
67-72-1	HEXACHLOROETHANE	1.E-02	b	1.0E-02	d
78-59-1	ISOPHORONE	2.E+00	b	2.0E+00	d
98-95-3	NITROBENZENE	5.E-03	b	6.0E-03	d
62-75-9	N-NITROSODIMETHYLAMINE	na		na	
621-64-7	N-NITROSO-DI-N-PROPYLAMINE	na		na	

Table 8-2 (Page 3 of 5)
SUBCHRONIC TOXICITY VALUES

CAS Number	Chemical	Subchronic RfD (oral) (mg/kg-day)	References	Subchronic RfD (inh) (mg/kg-day)	References
86-30-6	N-NITROSODIPHENYLAMINE	na		na	
87-86-5	PENTACHLOROPHENOL	3.E-02	b	3.0E-01	d
108-95-2	PHENOL	6.E-01	b	6.0E+00	d
110-86-1	PYRIDINE	1.E-02	b	1.0E-02	d
Volatile Organic Chemicals (VOCs)					
71-43-2	BENZENE	3.E-02	c	1.7E-01	d
100-41-4	ETHYLBENZENE	1.E+00	c	5.7E+01	d
1634-04-4	METHYL-T-BUTYL ETHER	5.E-02	a	8.6E+00	d
1330-20-7	M-XYLENE & P-XYLENE	2.E+01	c	2.0E+01	d
1330-20-7	O-XYLENE	2.E+01	c	2.0E+01	d
108-88-3	TOLUENE	2.E+00	b	3.0E-01	d
1330-20-7	XYLENES (TOTAL)	2.E+01	c	2.0E+01	d
630-20-6	1,1,1,2-TETRACHLOROETHANE	3.E-02	b	3.0E-01	d
71-55-6	1,1,1-TRICHLOROETHANE	9.E+00	a	2.9E+00	d
79-34-5	1,1,2,2-TETRACHLOROETHANE	1.E-03	a	6.0E-01	d
79-00-5	1,1,2-TRICHLOROETHANE	4.E-02	b	4.0E-02	d
75-34-3	1,1-DICHLOROETHANE	1.E+00	b	1.0E+00	d
75-35-4	1,1-DICHLOROETHENE	9.E-03	b	9.0E-02	d
563-58-6	1,1-DICHLOROPROPENE	3.E-03	c	6.0E-02	d
87-61-6	1,2,3-TRICHLOROBENZENE	1.E-01	c	1.0E-01	d
96-18-4	1,2,3-TRICHLOROPROPANE	6.E-02	b	5.0E-02	d
120-82-1	1,2,4-TRICHLOROBENZENE	1.E-02	b	1.0E-01	d
95-63-6	1,2,4-TRIMETHYLBENZENE	5.E-01	c	1.7E-02	d
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	6.E-04	c	5.7E-04	d
106-93-4	1,2-DIBROMOETHANE	2.E-03	b	5.7E-04	d
95-50-1	1,2-DICHLOROBENZENE	9.E-01	c	6.0E-01	d
107-06-2	1,2-DICHLOROETHANE	3.E-01	c	1.4E-02	d
78-87-5	1,2-DICHLOROPROPANE	1.3.E-02	b	1.0E-02	d
108-67-8	1,3,5-TRIMETHYLBENZENE	5.E-01	c	1.7E-02	d
541-73-1	1,3-DICHLOROBENZENE	9.E-03	c	9.0E-03	d
106-46-7	1,4-DICHLOROBENZENE	2.5.E+00	b	2.0E+00	d
123-91-1	1,4-DIOXANE	na		na	
594-20-7	2,2-DICHLOROPROPANE	1.E-02	c	1.0E-02	d
78-93-3	2-BUTANONE(MEK)	2.E+00	b	2.9E-01	e
110-75-8	2-CHLOROETHYLVINYL ETHER	na		na	
95-49-8	2-CHLOROTOLUENE	2.E-01	b	2.0E-01	d
591-78-6	2-HEXANONE	8.E-01	c	2.3E-01	d
106-43-4	4-CHLOROTOLUENE	2.E-01	c	2.0E-01	d
108-10-1	4-METHYL-2-PENTANONE(MIBK)	8.E-01	c	2.3E-01	d
67-64-1	ACETONE	1.E+00	b	1.0E+00	d
75-05-8	ACETONITRILE	6.E-02	b	1.7E-01	d
107-02-8	ACROLEIN	2.E-01	c	5.7E-05	d
107-13-1	ACRYLONITRILE	1.E-02	b	5.7E-03	d
107-05-1	ALLYL CHLORIDE	5.E-01	c	2.9E-03	e
100-44-7	BENZYL CHLORIDE	na		na	
108-86-1	BROMOBENZENE	2.E-01	c	2.9E-02	d
74-97-5	BROMOCHLOROMETHANE	2.E-01	c	2.0E-01	d
75-27-4	BROMODICHLOROMETHANE	2.E-02	b	2.0E-01	d
75-25-2	BROMOFORM	2.E-01	b	2.0E-01	d
74-83-9	BROMOMETHANE	1.E-02	c	1.0E-02	d

Table 8-2 (Page 4 of 5)
SUBCHRONIC TOXICITY VALUES

CAS Number	Chemical	Subchronic RfD (oral) (mg/kg-day)	References	Subchronic RfD (inh) (mg/kg-day)	References
75-15-0	CARBON DISULFIDE	1.E-01	b	3.0E-02	d
56-23-5	CARBON TETRACHLORIDE	7.E-03	c	7.0E-03	d
108-90-7	CHLOROBENZENE	2.E-01	c	6.0E-02	d
75-00-3	CHLOROETHANE	4.E+00	c	2.9E+01	d
67-66-3	CHLOROFORM	1.E-02	b	1.0E-01	d
74-87-3	CHLOROMETHANE	2.E-01	a	8.6E-01	d
126-99-8	CHLOROPRENE	2.E-01	c	2.0E-02	d
156-59-2	CIS-1,2-DICHLOROETHENE	1.E-01	b	1.0E-01	d
10061-01-5	CIS-1,3-DICHLOROPROPENE	2.E-01	b	6.0E-02	d
108-94-1	CYCLOHEXANONE	5.E+01	c	5.0E+01	d
124-48-1	DIBROMOCHLOROMETHANE	2.E-01	b	2.0E-01	d
75-71-8	DICHLORODIFLUOROMETHANE (Freon 12)	9.E-01	b	5.7E-01	d
64-17-5	ETHANOL	na		na	
87-68-3	HEXACHLOROBUTADIENE	2.E-03	c	2.0E-03	d
74-88-4	IODOMETHANE	na		na	
78-83-1	ISOBUTYL ALCOHOL	3.E+00	b	3.0E+00	d
98-82-8	ISOPROPYLBENZENE	1.E+00	c	1.1E+00	d
126-98-7	METHACRYLONITRILE	1.E-03	b	2.0E-03	d
80-62-6	METHYL METHACRYLATE	8.E-02	b	2.0E+00	d
75-09-2	METHYLENE CHLORIDE	6.E-02	b	1.4E-01	d
1634-04-4	METHYL-T-BUTYL ETHER	5.E-02	a	8.6E+00	d
91-20-3	NAPHTHALENE	2.E-01	c	8.6E-03	d
104-51-8	N-BUTYLBENZENE	1.E-01	c	1.0E-01	d
103-65-1	N-PROPYLBENZENE	1.E-01	c	1.0E-01	d
1330-20-7	O-XYLENE	2.E+01	c	2.0E+01	d
76-01-7	PENTACHLOROETHANE	1.E-02	c	1.0E-02	d
99-87-6	P-ISOPROPYL TOLUENE	2.E+01	c	2.0E+01	d
107-12-0	PROPIONITRILE	6.E-02	c	1.7E-01	d
135-9-88	SEC-BUTYLBENZENE	1.E-01	c	1.0E-01	d
100-42-5	STYRENE	2.E+00	c	8.6E-01	e
98-06-6	T-BUTYLBENZENE	1.E-01	c	1.0E-01	d
127-18-4	TETRACHLOROETHENE (PCE)	1.E-01	b	1.0E-01	d
109-99-9	TETRAHYDROFURAN	2.E+00	c	8.6E-01	d
156-60-5	TRANS-1,2-DICHLOROETHENE	2.E-01	b	2.0E-01	d
10061-02-6	TRANS-1,3-DICHLOROPROPENE	3.E-03	b	6.0E-02	d
110-57-6	TRANS-1,4-DICHLORO-2-BUTENE	na		na	
79-01-6	TRICHLOROETHENE (TCE)	6.E-02	c	6.0E-02	d
75-69-4	TRICHLOROFLUOROMETHANE	7.E-01	b	2.0E+00	d
-na-	TRIHALOMETHANES (TOTAL)	na		na	
108-05-4	VINYL ACETATE	1.E+00	b	5.7E-02	e
75-01-4	VINYL CHLORIDE	na		na	

Table 8-2 (Page 5 of 5)
SUBCHRONIC TOXICITY VALUES

CAS Number	Chemical	Subchronic RfD (oral) (mg/kg-day)	References	Subchronic RfD (inh) (mg/kg-day)	References

Key:
PRG= Preliminary Remediation Goals
CAS= Chemical Abstracts Service
USEPA= U.S. Environmental Protection Agency
CSF= Cancer Slope Factor
RfD= Reference Dose
inh= Inhalation
Cal-EPA= California Environmental Protection Agency
mg/kg= milligrams per kilogram
na= regulatory approved toxicity criteria not available or not applicable

Subchronic Oral Toxicity Values selected or derived with the following priorities:

1. Subchronic oral RfDs were taken from USEPA (1997) Health Effects Summary Tables.
2. Subchronic oral RfDs were derived from Cal-EPA oral RfDs by applying (muliplying by) a factor of ten.
3. Subchronic oral RfDs were dervived from USEPA oral RfDs by applying (muliplying by) a factor of ten.

Subchronic Inhalation Toxicity Values were derived with the following priorities:

1. Subchronic inhalation RfCs, taken from USEPA (1997) Health Effects Summary Tables were converted to inhalation RfDs by muliplying the RfC by a factor of (20 m^3/day / 70 kg).
2. Subchronic inhalation RfDs were derived from Cal-EPA chronic inhalation RfDs by applying (multiplying by) a factor of ten.

References

a. Subchronic oral RfDs were derived from Cal-EPA oral RfDs by applying (muliplying by) a factor of ten.
b. Subchronic oral RfDs were taken from USEPA (1997) Health Effects Summary Tables.
c. Subchronic oral RfDs were dervived from USEPA oral RfDs by applying (muliplying by) a factor of ten.
d. Subchronic inhalation RfDs were derived from Cal-EPA chronic inhalation RfDs by applying (multiplying by) a factor of ten.
e. Subchronic inhalation RfCs, taken from USEPA (1997) Health Effects Summary Tables were converted to inhalation RfDs by muliplying the RfC by a factor of (20 m^3/day / 70 kg).

*See Table 8-1 for specific USEPA and Cal-EPA sources of chronic oral and inhalation RfDs.

SECTION 9
RISK DECISION CRITERIA

In this section, risk decision criteria are established to develop a consistent approach to setting remedial action requirements for the subject property. It is important to understand that the decision criteria specified must be used and interpreted in light of the fact that the risk assessment process provides some, but not all, of the necessary information to facilitate risk management decisions. Risk assessment procedures may be used to answer the following questions:

- Is a remedial response required to protect public health?
- To what extent must a site be remediated to achieve such protection?
- What human health risks might be caused by a remedial action, and is a planned response less advisable?

The other factors that must be taken into account in making the final risk management decision include implementability, effectiveness (including meeting regulatory requirements), and cost.

In discussing risk decision criteria in this section, the focus is only on judgments to be made based on the results of the risk assessment. Therefore, the decisions discussed here are restricted to those recommending either (1) no further action based on risk or (2) further consideration to determine if a remedial response is necessary. Final remedial decisions cannot be made without consideration of the other previously noted factors. The risk assessor's role in making these recommendations is limited to answering the three questions posed above.

Thus, the principal objective of this section is to define an "acceptable" risk level that is too small to justify use of risk management resources. This is sometimes termed a *de minimis* risk (Young 1987; Paustenbach 1987). Later in the risk management process, risks greater than those considered *de minimis* may be considered acceptable, based on other factors. However, for present purposes, acceptable and *de minimis* will be used interchangeably.

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The information provided in human health risk assessments specifically utilized by risk managers[1] consists of the risk characterization results for both cancer and noncancer endpoints (DTSC 1993[2]; USEPA 1989, 1991a, 1992b,e, 1998). Numerical estimates of site-specific excess (incremental) cumulative cancer risks and noncancer hazard indices are compared to acceptable target values by risk managers. There is some variability in acceptable risk and target hazard indices established by various regulatory agencies, although most risk estimates considered acceptable lie within the risk range of 10^{-6} to 10^{-4}, and the target level for hazard indices is generally less than or equal to 1.

An additional consideration in making decisions is the level of confidence one has in the risk estimates. Thus, one might accept a higher risk, if there was high certainty that the exposure was extremely unlikely to have been underestimated. Alternatively, a more conservative risk target might be set for uncertain estimates. These considerations argue for a comprehensive evaluation of the uncertainty or variability in risk estimates, an approach supported by USEPA directives (USEPA 1992a). Evaluation of uncertainty is further discussed in Section 10.

Examination of both central tendency (i.e., CTE) and high end (i.e., RME) risk estimates allows the risk manager to place the high end risk value into perspective relative to the range of potential upper bound risks (USEPA 1992e). Accordingly, this deterministic approach, at a minimum, will be used in exposure area-specific risk assessments. A fully quantitative uncertainty analysis (i.e., probabilistic risk characterization using parameter distributions) may be performed to provide the risk manager with a more complete characterization of risk. The following discussion of risk decision criteria contains factors relating to the relative differences in risk estimates at the RME versus the CTE.

9.1 INCREMENTAL CANCER RISK

Potential cancer risk, as estimated by the assessment process, is the cumulative (i.e., produced by summation of risks associated with all potential exposures to all COPCs by all complete pathways) incremental risk attributed to the site and is independent of risks associated with non-site-related chemical exposures and other background cancer risks.

[1] Defined by USEPA (1989) as the individual or group of individuals who serve as the primary decision-maker for a site.

[2] DTSC's Supplemental Guidance for *Human Health Multimedia Risk Assessment* states in the foreword (page ii) that "*multimedia human health risk assessments prepared for sites or facilities over which DTSC has jurisdiction must conform to the guidance in the HHEM and OSWER Directives.*" It is inferred from this that USEPA guidance and directives also represent DTSC policy.

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Incremental risks of 10^{-6} to 10^{-4} correspond to theoretical[3] probabilities of 1 chance in 1 million to 1 chance in 10,000, which is in addition to or in excess of the background cancer risk. This is an extremely small increment above the background cancer risk, which is approximately 3 chances in 10 in the U.S. population over a lifetime as estimated by the National Cancer Institute. Expressed mathematically, the range of incremental risks of 10^{-6} to 10^{-4} correspond to an overall cancer risk of 3.000001 to 3.0001 chances in 10, respectively, an increase that would not be measurable under most circumstances. The conservatism of such risk increments is enhanced by the fact that risk is typically expressed as an upper bound excess cancer risk. That is, true risk is anticipated to lie somewhere between zero and the upper bound risk estimated in the risk characterization (USEPA 1986, 1989). As such, the use of any risk within this range appears to be suitably small to constitute *de minimis*.

Acceptable multimedia exposure levels, which consider dose and response for known or suspected carcinogens are generally concentration levels that represent an excess upper bound individual lifetime cancer risk of 10^{-6} or less. The 10^{-6} risk level is the generally accepted "point of departure" for selection of remedial alternatives. Potential risk estimates between 10^{-6} and 10^{-4} and require risk management decisions based on site-specific land use/exposure scenarios and may require remediation. Risk estimates that are greater than 10^{-4} generally require remediation to reduce potential exposures.

Cal-EPA is less explicit in the definition of acceptable risk, although DTSC's specification that EPA Superfund Guidance and Directives are applicable (DTSC 1993) suggests the USEPA risk range is appropriate. Cal-EPA's Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) establishes a "no significant risk" level at 10^{-5} (CHSC 1986), the midpoint of the *de minimis* risk range. These programs arguably address exposures to potentially larger populations than the hazardous waste programs (i.e., drinking water or air exposures would affect communitywide or statewide populations, whereas waste site exposures are limited to smaller groups of real or hypothetically exposed residents). These Cal-EPA programs apply site-specific economic and social considerations to select a site-specific risk management risk level within the *de minimis* range. Therefore, where deterministic risk assessment has been conducted for a site, the acceptable determinant risk level will be applied to the RME, as specified by USEPA (1989). This target value will be a cumulative cancer risk of 10^{-5}. It

[3] The risk is a theoretical value (based on the assumptions used in the toxicity and exposure assessments), and not an actual (e.g., based on statistical trends reported for the population) risk.

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will be recommended to risk managers that exposure areas with estimated risks exceeding this target be considered for risk management responses, while no further action will be recommended for risks less than this threshold:

Criteria for deterministic cancer risk estimate:

(1) no further action if risk $<10^{-5}$
(2) further consideration of remedial action, if risk $>10^{-5}$

Where probabilistic approaches have been employed, 10^{-5} will generally be applied as the acceptable risk threshold and will refer to a reasonably high end exposure RME. A "high end RME " exposure, by USEPA definition (USEPA 1992a), is an exposure that applies to the upper percentiles of the distribution of exposures (the remainder of the exposed populations would have less exposure and hence less risk).

However, where probabilistic methods have been used, observed risk levels in more central portions of the distribution should be inspected before a risk decision is made. This allows risk management decisions to account for "skewness" of the distribution and what it may mean for overall risk within a hypothetical population.

9.2 HAZARD INDEX

Noncancer risk assessment will employ the HI method. The HI evaluation process typically occurs in two steps: (1) hazard quotients for all compounds and all exposure pathways are added and compared to a target HI. If the calculated value is greater than the target, (2) only hazard quotients for those compounds anticipated to be additive in their action are summed to refine the HI estimate. As described in Section 10, this process will be used in risk assessments at the subject property.

As with cancer risk, it is of interest to determine where in the exposure distribution the decision criteria should be applied. Recognizing that an HI of less than 1 indicates that it is extremely unlikely that toxic effects will not occur during a lifetime in an exposed population, including sensitive subpopulations (USEPA 1989), it is arguable that the HI target should be applied to a more central portion of the population; i.e., that extreme exposures combined with assumptions of extreme sensitivity may cause risk decisions to be made on predicted events that are, in fact, extraordinarily rare.

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Almost all environmental programs employ an HI of unity as a target for risk decisions[4]. The most explicit directive comes from the federal Superfund program (OSWER Directive 9355.0-30; USEPA 1991b), which is inferred to be DTSC policy as well. This directive specifies an HI of 1 as the target for risk management decisions, as well as the target risk to be achieved in designing remedial responses. Accordingly, an HI of 1 will be used as the decision threshold for exposure area-specific risk assessments and will be applied to the RME.

Criteria for deterministic HI:

(1) no further action if HI <1

(2) separate HI calculations based on additive actions if total HI >1

(3) further consideration of a remedial action if HI >1 after separation described in (2)

9.3 SPECIAL CASE - LEAD

Potential human health effects of lead are typically inferred from blood lead levels, rather than intake and, as such, are not amenable to the HQ/HI approach. As noted in Section 5, lead will be evaluated using the Lead Spread model (DTSC 1992). The blood lead concentration identified as acceptable, for both children and adults, is 10 micrograms per deciliter (µg/dL) (DTSC 1992) and will be applied to high end (i.e., RME) exposure estimates. As recommended by DTSC (1992), the 90th, 95th, 98th and 99th percentile blood lead concentrations predicted by the model will be evaluated for both children and adults. While DTSC identifies the 99th percentile blood lead as a "point of departure" (e.g., remedial actions would never be implemented when predicted blood lead levels are at or below 10 µg/dL), non-risk-based risk management decisions may consider assessment of the 90th, 95th, and 98th percentile blood lead levels predicted by the model.

[4] Certain programs, such as the federal Safe Drinking Water Act, employ a target hazard quotient of less than 1. However, this is to account for the potential presence of several chemicals in a water supply, or alternate sources of the compound, which might cause the HI to exceed 1.

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9.4 RISK ASSESSMENT AS AN AID TO REMEDIAL RESPONSE

In the event a remedial action is planned, risk assessment will aid in the design of the action by specifying those media and exposure routes that are particularly important and the concentration of residual chemical that may be left in place with minimal risk. This may be done in one of two ways. Frequently, risk-based cleanups utilize a "remediation goal." This may be viewed as an acceptable residual concentration determined by "rearranging" the risk equation (i.e., as a backward calculation) to solve for a concentration that would not exceed a specified risk target. An alternative approach is to reiterate the "forward" risk assessment, substituting exposure point concentrations representing the estimates of what chemical reduction may be achieved by one or another remedial technology. For instance, one might rerun a risk assessment under the assumption that the highest concentration of a COPC observed in soil had been reduced to one-half the SQL, because the remedial design specified excavation of soil in that area of the site. If risk targets are achieved under this scenario, the design would be considered a good risk reduction strategy. If risk targets were still exceeded, the assessment could be rerun using a yet lower exposure point concentration representing a more extended excavation (either contiguous to the initial excavation, or moving to another area of high observed concentrations; these areas might be specified using the area-weighting approach discussed in Section 5). Further iterations may be required. An acceptable remediation in this example would be the extent of excavation supporting a final risk assessment indicating the target had been achieved.

An "iterative forward" assessment is advantageous because it avoids computational difficulties encountered where time-averaged exposure point concentrations have been used or where the risk estimate is based on probabilistic methods (Burmaster et al. 1995). Furthermore, the iterative method fosters interaction between remedial engineers and risk assessment specialists, which leads to more effective response. Finally, the methods and risk criteria for the forward risk assessment are explicit (as specified in this work plan), and no further computational methods require definition. Thus, it is herein proposed that an iterative forward calculation be used.

SECTION 10
HUMAN RISK CHARACTERIZATION

Risk characterization "...serves as the bridge between risk assessment and risk management and is therefore a key step in the ultimate site decision-making process" (USEPA 1989). Because the risk assessment plays such a critical role in ultimate site decisions, it is imperative that the results (i.e., the risk characterization) are clearly and accurately portrayed, and that a framework is provided for the interpretation of the results by reviewers and managers. Accordingly, the risk assessment will follow USEPA's recommended outline for presentation of the risk characterization (USEPA 1989). The primary components of the risk characterization are further discussed in the remainder of this section. In an effort to standardize the presentation of human health risk assessment data inputs and results, USEPA (RAGS, Part D 1998) has developed standardized reporting tables. Tables consistent with those presented in Risk Assessment Guidance for Superfund (RAGS) Part D will be used to summarize human health risk assessments for the subject property.

This comprehensive work plan is an integral part of the risk assessment presentation. Since many risk assessments will be prepared for the subject property, it is necessary to standardize and simplify the risk assessment report. It is therefore proposed that a template be followed for each of the risk assessments. An example of this template is presented in Appendix A. In general, it is proposed that the risk assessment text be consolidated and simplified into a one- to two-page format and that the results of the risk assessment (e.g., the COPC selection, calculations, and risk characterization) be presented in attached tables and figures. Examples of these tables and figures are also presented or described in Appendix A.

10.1 Characterization of Potential Carcinogenic Health Risks

Potential carcinogenic health risks will be characterized as the upperbound probability of an individual developing cancer over a lifetime as a result of exposure to a site-related chemical under specific exposure scenarios. The incremental probability of developing cancer (i.e., the theoretical incremental cumulative [above background] carcinogenic risk) is the risk attributed to exposure to COPCs at an exposure area (USEPA 1989), and is independent of chemical exposures of daily life not related to the subject property. For each COPC identified as a potential human carcinogen, the theoretical upperbound

incremental cumulative cancer risk is based on the LADI and a factor relating intake to cancer risk (the cancer slope factor, SF). SFs presented in Section 8 will be used to characterize carcinogenic risk. These values are, in general, upperbound estimates on the slope of the carcinogenic dose-response relationship. The following equation (USEPA 1989; DTSC 1992) will be applied to estimate cancer risk for each relevant exposure pathway:

$$\textit{Excess Cancer Risk} = \textit{LADI} \times \textit{SF} \qquad (10\text{-}1)$$

The calculations will be performed separately for children and adults. A total lifetime excess cancer risk will be calculated by first summing chemical-specific risks calculated for all complete pathways for both age groups, and then summing risks for all COPCs evaluated as potential carcinogens. This approach is conservative as different chemical classes (and often individual chemicals within a chemical class) often act by different mechanisms of action and at different target organs. In addition, the current regulatory approach assumes that exposure to a carcinogen at any dose will present some risk (USEPA 1986, 1996a). Cancer risk estimates will be expressed using one significant figure (USEPA 1989). If the deterministic exposure approach is used, risk estimates for both the CTE and RME will be presented as recommended by USEPA (1989, 1992b). A frequency distribution of risk estimates will be presented, if a probabilistic approach is used.

10.2 Characterization of Potential Noncarcinogenic Health Effects

Potential noncarcinogenic adverse health effects will be characterized by comparing predicted CTE and RME doses for each exposure area to RfDs (see hierarchy of information presented in Section 8). To calculate a hazard quotient (HQ), the ADI (e.g., upperbound intake averaged over the exposure period) for each relevant COPC will be divided by the chemical-specific RfD as shown in the following equation:

$$\textit{Hazard Quotient} = \textit{ADI/RfD} \qquad (10\text{-}2)$$

When available, pathway-specific RfDs will be applied. For each chemical, the HQs will be summed for all complete pathways to estimate the chemical-specific HQ. As a first tier analysis, all HQs (e.g., for all chemicals, regardless of target organ) will be summed as the basis for conservatively estimating a screening HI for each exposure scenario. If

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the result exceeds a value of 1.0, then target organ-specific HIs will be calculated based on target organs as recommended by USEPA (1989).

HIs will be calculated separately for chronic ($\geq$ 7 years), subchronic (2 weeks to 7 years) exposure periods as specified by USEPA (1989), using chronic and subchronic toxicity values, respectively, as described in Section 8. HIs will be expressed using appropriate significant figures for both CTE and RME scenarios (USEPA 1989, 1992b) in the case of deterministic assessment, or as a frequency distribution if probabilistic assessment is used.

10.3 Sensitivity Analysis

A sensitivity analysis will be performed to evaluate the magnitude of impact of exposure parameter values, exposure modeling assumptions, and toxicity values on the results of the exposure and risk estimates. This analysis differs from the uncertainty analysis described in Section 10.4 to the extent that the sensitivity analysis focuses on the mathematical relationships between variables used in the exposure and risk calculations and does not address the issues of uncertainty and variability of individual parameter values. The results of the sensitivity analysis will be used to focus the uncertainty analysis described in Section 10.4 on those variables that have the greatest impact on the risk results.

10.4 Assessment and Presentation of Uncertainty

As recommended by USEPA (1989, 1992b), an assessment of uncertainties in the risk characterization estimates will be presented. The risk estimates are based on conservative risk assessment methodologies and assumptions (applied to both the toxicity assessment and exposure assessment). Accordingly, it is critical that uncertainties associated with the conservative practices employed, as well as those associated with known or potential data gaps, be thoroughly addressed such that the numerical estimates are placed in the proper perspective by risk managers.

The risk assessment will identify and evaluate those COPCs with the greatest contribution to the cumulative risk (e.g., "risk drivers"). USEPA has defined risk drivers as "those chemicals which contribute at least 90% of the total estimated risk." Specifically, a percent contribution to risk (or hazard), by chemical and by pathway, will

be assessed and presented in graphic and tabular format and subsequent uncertainty analysis will focus on the identified risk drivers.

In the case of deterministic risk assessment, discussion of uncertainties will be largely qualitative. In the case of the probabilistic approach, a quantitative depiction of uncertainty assessment will be presented, as an enhancement to the qualitative discussion of uncertainty.

10.5 Risk Characterization for Lead

If lead is selected as a COPC, the current Cal-EPA Lead Spread model will be used to predict blood lead levels for both children and adults. Site-specific chemical concentration data will be used as the basis for soil ingestion, inhalation, and dermal contact pathways. Initially, default values (as provided in the model) will be used for dietary intake and drinking water intake pathways; however, site-specific data may be used.

The blood lead concentration identified as acceptable, for both children and adults, is 10 µg/dL (DTSC 1992). The Center for Disease Control (CDC) (1991) has identified the LOAEL for lead to be 10 µg/dL for children and 30 µg/dL for adults. As recommended by DTSC (1992), the 90th, 95th, 98th, and 99th percentile blood lead concentrations predicted by the model will be evaluated for both children and adults.

10.6 Presentation of Risk Characterization Results for Risk Managers

Because many factors must be weighed by the LARWQCB risk manager, it is imperative that risk assessment results be presented in a format that allows the LARWQCB risk manager to integrate and weigh decision factors appropriately and optimally.

USEPA emphasizes the importance of providing information to risk managers regarding key assumptions, rationale, and the extent of scientific consensus; the uncertainties associated with risk characterization estimates; and the effect of reasonable alternative assumptions on conclusions and estimates (USEPA 1992b). In particular, the risk manager should be able to understand which components of the risk assessment (e.g., chemicals, pathways, and assumptions) contribute most significantly to the results of the assessment. Both sensitivity and uncertainty analyses will be used to convey this

information. Pie charts or tables that show percent contribution to total risk (for chemicals as well as for pathways) are particularly useful to a risk manager who must integrate uncertainty into risk management decisions; accordingly, tables and charts will be used to present risk characterization results.

Since deterministic risk estimates do not provide any information regarding the distribution of risk, results of probabilistic risk assessments (when performed) will be used in the interpretation of deterministic risk estimates. Deterministic risk estimates based on the probabilistic results will be presented with respect to appropriate percentile benchmarks (i.e., 50th and 90th percentile of the distribution), and benchmark risk levels (i.e., 10^{-4}, 10^{-5}, 10^{-6}) will be presented with respect to the correlating percentile on the distribution. Similarly, deterministic HI estimates will be presented with respect to appropriate percentile benchmarks (i.e., 50th and 90th percentile of the distribution), and benchmark HIs (i.e., 0.1, 1.0, 10) will be presented with respect to the correlating percentile on the distribution.

A final risk management consideration is that of new data that may become available subsequent to completion of the risk assessments. When remedial action activities occur over a significant period of time (e.g., months to years), it is important for the risk manager to consider newly published information (site-specific and chemical-specific) as it becomes available to ensure that final site decisions are protective of humans and are based on all available information.

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SECTION 11
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APPENDIX A

EXAMPLE RISK ASSESSMENT REPORT TEMPLATE

APPENDIX A
TABLE OF CONTENTS

Example Risk Assessment Report Template

TABLE	TITLE
A-1	Occurrence, Distribution, and Selection of Chemicals of Potential Concern (COPC
A-2	Summary of Background Metals Evaluation
A-3	Selection of Exposure Pathways
A-4	Values Used for Daily Intake Calculations
A-5	Medium-Specific Exposure Point Concentration Summary
A-6	Calculation of Noncancer Hazards, Reasonable Maximum Exposure
A-7	Calculation of Cancer Risks, Reasonable Maximum Exposure
A-8	Uncertainty Analysis
A-9	Sensitivity Analysis
A-10	Risk Summary

PROJECT SITE MAP	EXPOSURE AREA MAP	EXPOSURE AREA DESCRIPTION

SITE CHARACTERIZATION

Historical Use of exposure area
Data Sources (summarize, and refer to attached table and figure containing summary of sampling and analysis)
Data validation and usability (summarize, and refer to attached table [Table A-1])

HAZARD IDENTIFICATION

COPC Selection (summarize, and refer to attached table [Table A-1])
Background Evaluation Results (summarize Comparison Method and Wilcoxon results, and refer to attached table [Table A-2])

CONCEPTUAL SITE MODEL

Receptors (summarize)
Exposure Pathways Analysis (summarize, and refer to attached table [Table A-3])

EXPOSURE ASSESSMENT

Soil EPC (summarize, and refer to attached table [Table A-4])
Groundwater EPC (summarize, and refer to attached table [Table A-4])
Fugitive Dust EPC (summarize, and refer to attached table [Table A-4])
Indoor Air VOC EPC (summarize, and refer to attached table [Table A-4])
Average Daily Intake Estimates (summarize, and refer to attached table [Table A-5])
Lifetime Average Daily Intake Estimates (summarize, and refer to attached table [Table A-5])

TOXICITY ASSESSMENT

Refer to the risk assessment work plan and summarize any revised or additional toxicity criteria

RISK CHARACTERIZATION

Noncancer Hazard Indices (summarize, and refer to attached table [Table A-6])
Incremental Cancer Risk Estimates (summarize, and refer to attached table [Table A-7])
Uncertainty Analysis (summarize and refer to attached table [Table A-8])
Sensitivity Analysis (summarize and refer to attached table [Table A-9])
Summary (summarize and refer to attached table [Table A-10])
Discussion
Recommendations

OGDEN

Table A-1
OCCURRENCE, DISTRIBUTION, AND SELECTION
OF CHEMICALS OF POTENTIAL CONCERN (COPC)

MEDIUM:

Chemical	Minimum[(1)] Concentration	Minimum Qualifier	Maximum[(1)] Concentration	Maximum Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of SQLs	Greater Than Background (Yes/No)	Greater Than 5% Detects (Yes/No)	COPC (Yes/No)	Rationale for Chemical Deletion

[(1)] Minimum/Maximum Detected Concentration
SQL = sample quantitation limit

Table A-2

SUMMARY OF BACKGROUND METALS EVALUATION [a]

Metal	Comparision Method			Wilcoxon Rank Sum Test	
	Exposure Area Range (mg/kg)	Site Background Range (mg/kg)	Exposure Area Consistent with Background ? (yes/no)	Wilcoxon Test Results (p value)	Exposure Area Consistent with Background ? (yes/no)
ALUMINUM	-	-			
ANTIMONY	-	-			
ARSENIC	-	-			
BARIUM	-	-			
BERYLLIUM	-	-			
CADMIUM	-	-			
CHROMIUM (Total)	-	-			
CHROMIUM III	-	-			
CHROMIUM IV	-	-			
COBALT	-	-			
COPPER	-	-			
LEAD	-	-			
MERCURY	-	-			
MOLYBDENUM	-	-			
NICKEL	-	-			
SELENIUM	-	-			
SILVER	-	-			
THALLIUM	-	-			
VANADIUM	-	-			
ZINC	-	-			

a. As described in Section 3 of the RAWP, the background metals evaluation using the Comparison Method will be performed first. If the results of the Comparision Method indicate that site metal concentrations are consistent with background metal concentrations, then the Wilcoxon Rank Sum Test will not be used. If the Comparison Method results suggest that site metal concentrations may not be consistent with background metal concentrations, then the Wilcoxon Test will be performed.

Table A-3
SELECTION OF EXPOSURE PATHWAYS

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway

Table A-4
MEDIUM-SPECIFIC EXPOSURE POINT CONCENTRATION SUMMARY

MEDIUM:

Chemical of Potential Concern	Units	CTE EPC	Method of Calculation	RME EPC	Method of Calculation

Table A-5
VALUES USED FOR DAILY INTAKE CALCULATIONS

Exposure Route	Parameter Code	Parameter Definition	Units	CTE Value	RME Value

Table A-6
CALCULATION OF NONCANCER HAZARDS
REASONABLE MAXIMUM EXPOSURE

Chemical of Potential Concern	Ingestion Intake (Non Cancer)	Ingestion Intake (Non-Cancer) Units	Dermal Intake (Non Cancer)	Dermal Intake (Non Cancer) Units	Oral Reference Dose	Oral Reference Dose Units	Ingestion Hazard Quotient	Dermal Hazard Quotient	Inhalation Intake	Inhalation Intake (Non Cancer) Units	Reference Concentration	Reference Concentration Units	Inhalation Hazard Quotient	Hazard Index

Total Hazard Index Across All Exposure Routes/Pathways:

Table A-7
CALCULATION OF CANCER RISKS
REASONABLE MAXIMUM EXPOSURE

Chemical of Potential Concern	Ingestion Intake (Cancer)	Ingestion Intake (Cancer) Units	Dermal Intake (Cancer)	Dermal Intake (Cancer) Units	Oral Cancer Slope Factor	Oral Cancer Slope Factor Units	Ingestion Risk	Dermal Risk	Inhalation Intake	Inhalation Intake (Cancer) Units	Inhalation Cancer Slope Factor	Inhalation Cancer Slope Factor Units	Inhalation Cancer Risk	Cancer Risk
Total Risk Across All Exposure Routes/Pathways:														

Table A-8
Uncertainty Analysis

Assumption	Potential Magnitude for Over-estimation of Exposure	Potential Magnitude for Under-estimation of Exposure	Comment
Exposure Assessment			
Sampling and Analysis			
1			
2			
3			
4			
5			
Fate and Transport Modeling			
1			
2			
3			
4			
5			
Exposure Parameter Estimation			
1			
2			
3			
4			
5			
Toxicity Assessment			
Cancer Slope Factors			
1			
2			
3			
4			
5			
Reference Doses			
1			
2			
3			
4			
5			

Table A-9
Sensitivity Analysis

Assumption	Range of Values		Potential Magnitude of Impact on Risk Estimates
	Low End of Range	High End of Range	
Exposure Assessment			
Fate and Transport Modeling Parameter Values			
1		-	
2		-	
3		-	
4		-	
5		-	
6		-	
7		-	
8		-	
9		-	
10		-	
11		-	
12		-	
13		-	
14		-	
15		-	
Human Exposure Parameter Values			
1		-	
2		-	
3		-	
4		-	
5		-	
6		-	
7		-	
8		-	
9		-	
10		-	
11		-	
12		-	
13		-	
14		-	
15			

Table A-10
RISK SUMMARY

Medium	Exposure Medium	Exposure Point	Cancer Risk					Hazard Index				
			Ingestion	Dermal	Inhalation	Total	COPC Contributing Majority of Risk	Ingestion	Dermal	Inhalation	Total	COPC Contributing Majority of Risk